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THESIS

AN ANALYSIS OF THE 1977 AD/AR TARSLL

by

James Wiley Hargrove, Jr.

September 1980

Thesis Advisor F. R. Richards

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The industrial mission of Destroyer Tenders (AD) and Repair Ships (AR) is to provide intermediate level maintenance and repair for supported ships. The Tender and Repair Ship Load List for these ships (AD/AR TARSLL) designates the range (number) and depth (quantity) of repair parts to be carried to support this industrial mission. This thesis details the logical reasoning and mathematical theory used to develop the 1977 AD/AR TARSLL, including an analysis

20. (continued)

of the data development, the mathematical inventory model and procedures used, and various assumptions and constraints applied during the process. Actual demand history for the six AD/AR's in the Atlantic fleet for a two year period from 1977 to 1979 was used to evaluate the effectiveness of the load list. The effects of certain assumptions in the model on the load list were analyzed. The proposed changes for the 1980 TARSLL were incorporated in the 1977 TARSLL and evaluated. Also, alternative models and methods of load list development were proposed and evaluated.

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An Analysis of the 1977 AD/AR TARSLL

by

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Submitted in partial fulfillment of the
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from the

NAVAL POSTGRADUATE SCHOOL
September 1980

ABSTRACT

The industrial mission of Destroyer Tenders (AD) and Repair Ships (AR) is to provide intermediate level maintenance and repair for supported ships. The Tender and Repair Ship Load List for these ships (AD/AR TARSLL) designates the range (number) and depth (quantity) of repair parts to be carried to support this industrial mission. This thesis details the logical reasoning and mathematical theory used to develop the 1977 AD/AR TARSLL, including an analysis of the data development, the mathematical inventory model and procedures used, and various assumptions and constraints applied during the process. Actual demand history for the six AD/AR's in the Atlantic fleet for a two year period from 1977 to 1979 was used to evaluate the effectiveness of the load list. The effects of certain assumptions in the model on the load list were analyzed. The proposed changes for the 1980 TARSLL were incorporated in the 1977 TARSLL and evaluated. Also, alternative models and methods of load list development were proposed and evaluated.

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I. GENERAL BACKGROUND AND INTRODUCTION

A. DEFINITION AND PURPOSE OF THE TARSLL

The industrial mission of Destroyer Tenders (AD) and Repair Ships (AR) is to provide intermediate level maintenance and repair for supported ships. The Tender and Repair Ship Load List for these ships (AD/AR TARSLL) designates the range (number) and depth (quantity) of repair parts to be carried to support this industrial mission for a specific period of time. A separate load list is developed for the Atlantic and Pacific fleets. Each Destroyer Tender or Repair Ship in the same fleet carries the same load of items. This load has been designated as Prepositioned War Reserve Stock (PWRS) by the Chief of Naval Operations (CNO) and as such is not only to be responsive to peacetime demands but also to satisfy wartime requirements. The normal support period is therefore specified as ninety (90) days since this is considered the required support period for a wartime environment without resupply. The CNO has also set an 85 percent net requisition effectiveness goal for the AD/AR TARSLL. This means that 85 percent of all of the requisitions submitted in a 90 day period for items carried by the TARSLL should be completely filled from stock. This excludes requisitions from supported ships for resupply of their stock since the TARSLL is not designed to support this. A new TARSLL is produced about every three years. Prior to 1979 the Fleet Material Support Office (FMSO) was responsible for development of the TARSLL model and production of the actual load list. The production function is now the responsibility of the Ship's Parts Control Center (SPCC).

B. PROBLEMS WITH THE 1977 AD/AR TARSLL

The AD/AR TARSLL developed in 1977 for the Atlantic fleet had a per ship range of about 13,000 different line items and a per ship value over $750,000. In August 1979 the Commander Naval Surface Force Atlantic Fleet (the type commander for Atlantic fleet tenders and repair ships) critized the 1977 AD/AR TARSLL for not being responsive to fleet needs. In particular he claimed that over 9000 of the load list items had no demand for two years. The current model is about 16 years old and has not undergone a complete analytic review since inception, although there have been several interim changes to correct apparent deficiencies. Some people involved in the development of the 1980 TARSLL at SPCC have recommended several changes in the methodology and parameters used in the model prior to development of the 1980 TARSLL. The more important changes concern the criteria for determining the range of items to be carried, the essentiality of items, and the average quarterly demand for items without a demand history. FMSO has been tasked by the Naval Supply Systems Command (NAVSUP) to review the AD/AR TARSLL development process and recommend procedural changes for the 1980 load list.

C. THESIS PURPOSE

The purpose of this thesis is to detail the logical reasoning and mathematical theory used to develop the 1977 AD/AR TARSLL, including an analysis of the data development, the mathematical inventory model and procedures used, and various assumptions and constraints applied during the process. Actual demand history for the six AD/AR's in the Atlantic fleet for a two year period from 1977 to 1979 will be used to evaluate the effectiveness of the load list. The effects of certain assumptions in the model on the load list will be analyzed. The proposed changes for the 1980 TARSLL

will be incorporated in the 1977 TARSLL and evaluated. Also, alternative models and methods of load list development will be proposed and evaluated. The scope of this thesis has been coordinated with FMSO to support their efforts in improving the 1980 AD/AR TARSLL.

II. GENERAL DESCRIPTION OF TARSLL DEVELOPMENT

A. GENERAL DESCRIPTION OF THE INVENTORY

There are two distinct categories of items considered in the development of the TARSLL. The first category is equipment related (ER) items which are load list candidates based on their identification to an equipment or component to be supported by the tender's repair capability. The other category is non-equipment related (NER) items which are load list candidates based on demand. If an item does not meet the criteria to be an ER candidate, but does have industrial demand reported in the last two years by a tender or repair ship to be supported by the load list, then this item is designated an NER candidate.

B. EQUIPMENT SUPPORT DETERMINATION

The first step in determining the ER candidate items is to list the ships by hull type and number to be supported by the tenders and repair ships of each fleet. This is called the hull mix. Once it is established, SPCC retrieves from its master files all Allowance Parts Lists (APL's) applicable to the hull mix. These APL's are then filtered through a component cut which basically eliminates from further consideration any APL's that are not applicable to at least seven ships in the hull mix. Of course the type commander can override the component cut for any APL. The repair parts appearing on the candidate APL's are then screened to eliminate those items that cannot be installed at the tender or repair ship level. The remaining items, plus any other identified by the type commander, become the ER candidate repair parts. During this last screening, the total quantity of each item installed in the supported ships is accumulated along with the lowest level at which the item

can be installed, i.e. either the load activity or the supported ship. Once the ER candidate items are identified, the SPCC master data files are entered to obtain additional information about the item, including price, minimum replacement quantity, and Best Replacement Factor (BRF). The meaning and use of the BRF will be explained later.

C. INPUT DEVELOPMENT

The next step is the retrieval of the historical demand data for these items. Destroyer Tenders and Repair Ships are a part of the Mobile Logistic Support Force (MLSF) and as such are required to report their parts demand monthly to SPCC. SPCC retains this data for 24 months on the MLSF demand file. In the retrieval process the 24 months of demand history for each item is summarized as eight quarters of demand quantity (number of units demanded) and demand frequency (number of times demanded). Only those demands identified for use in support of the tender or repair ship's industrial mission are extracted from the MLSF demand file. Additionally those items on the demand file that did not qualify as ER candidates are classified as NER candidates and their demand history is summarized as was done for the ER candidates.

D. RANGE AND DEPTH DETERMINATION

To determine the variety of items to be stocked, the model applies a range cut; that is, any item that has anticipated demand in the next two years greater than a specific level (the range cut parameter) will be stocked, and any item with anticipated demand less than the range cut parameter will not be stocked, subject of course to individual item quantity overrides. The range cut really determines the line items to be carried on the TARSLL, while all other calculations only determine the depth to be stocked. The range cut criterion is applied to each item as

it is being considered by the model. If an item does not pass the range cut, and is not forced on the load list by an override, the total demand quantity and total frequency of demand are accumulated, and then the next candidate is considered. If an item passes the range cut, it proceeds to the depth calculation. The model that is used for depth determination is a variable-protection-level, single-period-constrained, inventory model. The objective function is to minimize the total essentiality-weighted cost of the load, subject to the constraint that requisition effectiveness be at least 85 percent. Essentiality-weighted cost is used in the objective function to provide increased depth for more essential items in a wartime environment. The problem is solved by an iterative process based on a Lagrange multiplier approach. The variable input risk parameter (the Lagrange multiplier) is set and the essentiality-weighted cost equation is solved for the risk factor. The stock level for each item is set by using the risk factor to adjust the predicted demand, which is assumed to be normally distributed, subject to various constraints. After these preliminary stock levels are set, a prediction routine is run to estimate the net requisition effectiveness. If the desired 85 percent effectiveness is achieved, then the TARSLL is set. If the desired effectiveness is not achieved, then a new risk parameter is input and the process is repeated.

E. TARSLL IMPLEMENTATION

Once the load list has been determined by the computer model, a series of listings are output for review by SPCC. These listings allow an analyst to review the load list in several different forms to determine if additional items should be deleted from the TARSLL based on quantity, price, or demand frequency. After these "post model" changes have been made, the financial statistics for the final TARSLL are

forwarded to NAVSUP for approval. Upon approval, a tape with the load list items and all data necessary for requisitioning is provided to each load list carrying activity. There it is merged with other "ship's stock" to determine the quantity to be ordered. Throughout the life of the TARSLL, adjustments can be made by individual ships based on actual demand. Additional items may be stocked if there are four demands in 12 months and additional quantities of a stocked item may be carried if certain quantity and frequency of demand criteria are met.

III. DESCRIPTION OF THE INVENTORY MODEL

The procedure described in this chapter is not the result of the rigorous application of inventory theory. Instead, it has evolved over time through the process of trial and error. There have been many patches made to correct apparent deficiencies in the model, as evidenced by the many overrides and constraints. Consequently, there is no theoretical discussion of the inventory model in the basic documentation for the process. The mathematical model presented later in this chapter, therefore, is necessarily the result of reverse derivation from the mechanics of the procedure. The model was derived to provide some insight into the objectives and basic constraints of the procedure, and should be viewed from this perspective.

A. FORECASTING EXPECTED DEMAND

The first steps toward the determination of the range and depth of items to be carried on the TARSLL are the computations of the average quarterly demand (AQD), the standard deviation of demand (SIGMA), and the average requisition size (A). For items with demand history, AQD is the straight average of the eight quarters of demand. For items without any demand history, the Best Replacement Factor (BRF) for the item and its installed population are used to estimate the average quarterly demand. The BRF for each item is the expected number of times an item will require replacement in one year. Since the BRF is developed based on all usages of the item, it may not reflect the expected replacement rate in the equipments supported by the TARSLL. The following formula is used to determine the average quarterly demand:

$$AQD = 1/4\ BRF\left[(POPs \times K2) + (POPt \times K3)\right]$$

POPs is the fleet population of the item that is installable at the organizational (shipboard) level;

POPt is the fleet population of the item that is installable at no lower than the tender level;

K2 is the fraction of the item's population installable at the organizational level that is to be supported by the tender;

K3 is the fraction of the item's population that can be installed at the tender level that is to be supported by the tender.

K2 and K3 indicate the probability that the tender or repair ship will see a demand for parts installable at the different levels of maintenance. The value of K2 is set to be 0.1. This means that a tender or repair ship should replace a part installable at the organizational level only 10 percent of the time the part fails. The value of K3 is set at .33 which means that a tender or repair ship should replace a part installable at no lower than the tender level 33 percent of the time. If AQD computes to zero then a value of 0.001 is used. The standard deviation for items with demand history is computed as follows:

$$\mathrm{SIGMA} = \sqrt{\frac{\sum_{i=1}^{n} (Di - AQD)^2}{8}} \quad ,\text{where}$$

Di is the demand for quarter i.

For items with no demand history SIGMA is taken to be 1.6xAQD if AQD is greater than or equal to 1.0 and 2.1xAQD otherwise. If AQD was forced to be 0.001 then SIGMA is forced to be 0.0001. The average quarterly demand and the standard deviation are then supposed to be factored by the number of ships using the TARSLL to reduce demand data from an ocean level to an individual ship level. In the development of the 1977 TARSLL, however, there was no factoring of either AQD or SIGMA. For items with demand history, the average requisition size, A, is equal to the total demand quantity divided by the total demand frequency. For all other items, A is set to one.

B. RANGE CUT PROCESS

Once the AQD has been predicted, the range of items to be carried can be determined. This is done by the range cut process which is distinct from the depth determination process. If an item has a predicted two-year demand (8xAQD) greater than or equal to the range cut value, the item is stocked. Otherwise, it is not stocked. An item passing the range cut then goes to the depth computation. However, should the computed depth be less than one, the range cut process forces the load-list quantity to be one.

C. DETERMINING ESSENTIALITY

To determine the depth of an item, its essentiality must first be computed. For items without demand history, i.e. demand was estimated by the BRF method, the essentiality factor E is computed by the following equation:

$$E=\frac{POPs \times Ks \times e^{-(116-MECs)ALPHs} + POPt \times Kt \times e^{-(58-MECt)ALPHt}}{POPs + POPt}$$

POPs is the fleet population of the item that is installable at the organizational level;

POPt is the fleet population of the item that is installable at no lower than the tender level;

Ks is a parameter used to weight the applications installable at the organizational level (value $\leq$ 1);

Kt is a parameter used to weight the applications installable at no lower than the tender level (value $\leq$ 1);

MECs is the military essentiality code of those items installable at the organizational level (maximum value is 116);

MECt is the military essentiality code for those items installable at no lower than the tender level (maximum value is 58);

ALPHs is a parameter used to control the range of essentiality for items installable at the organizational level (equals .12);

ALPHt is a parameter used to control the range of essentiality for items installable at no lower than the tender level (equals .12).

Ks and Kt indicate the relative essentiality of parts

installable at the different levels of maintenance. The current values of Ks and Kt are .67 and 1.0 respectively, indicating that parts installable at no lower than the tender level are 50 percent more essential to the tender's repair mission than are parts installable at the organizational level. It should be noted that, in all cases, the value of E computed by the above equation will be less than one. Should E compute to zero, then a default value, which is currently unity, is used. For items that have average quarterly demand estimated from historical data, AQD is used as the measure of essentiality (i.e. E=AQD). This is designed to increase the depth of items with historical demand, since the range cut forces the AQD to be greater than one.

D. COMPUTING LOAD LIST QUANTITIES

Once these variables have been determined, they become inputs to the depth computation, which is the only place where the mathematics of the single period constrained inventory model is used. The assumed model is :

$$\text{minimize} \quad \sum_{i=1}^{n} Ci \times Zi / Ei$$

$$\text{subject to} \quad \frac{\sum_{i=1}^{n} \frac{(Ui - Vi)}{Ai}}{Ui/Ai} \geq .85$$

Ci is the unit cost for item i;

Ei is the essentiality for item i;

Zi is the quantity stocked of item i;

Ui is the average quarterly demand for item i;

Vi is the average quarterly units short for item i;

Ai is the average requisition size for item i.

The solution of this model is by the Lagrange multiplier method. Assuming a normal distribution for demand, the following equations are obtained:

1. $Zi = Ui + Si \times \Phi^{-1}\left(\frac{Ci \cdot Ai}{Ei \cdot \theta}\right) \qquad i=1,2,3,\ldots n$

2. $$.15 \sum_{i=1}^{n} \frac{Ui}{Ai} = \sum_{i=1}^{n} Si\left[\emptyset\left(\frac{Zi-Ui}{Si}\right) - \left(\frac{Zi-Ui}{Si}\right)\Phi\left(\frac{Zi-Ui}{Si}\right)\right],$$ where

θ is the Lagrange multiplier

Si is the standard deviation for item i;

$\emptyset$ is the density of the normal distribution;

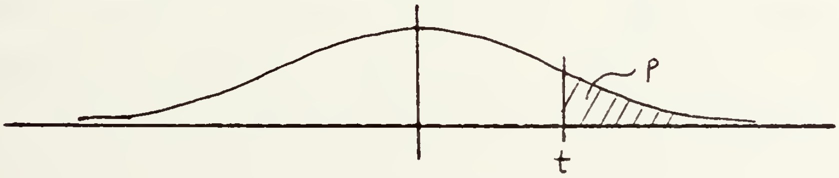
Φ is the cumulative distributiion function of the normal distribution.

Equations 1. and 2. must be solved simultaneously for Zi and 0. The iterative approach is used for solution. The Lagrange multiplier is fixed, the quantities Zi are computed for each item using equation 1, and then equation 2 is solved to determine effectiveness. The Lagrange multiplier is changed and new Zi are computed until constraint equation 2 is satisfied.

The controlling term in the solution of the model is the Lagrange multiplier. In the TARSLL computations, the risk parameter λ is defined as $1/\theta$ and the following is called the risk equation:

$p = \lambda CA/E$ where p is the "risk"

A quick look at the term $\Phi^{-1}\left(\frac{C\cdot A}{E\cdot\theta}\right) = \Phi^{-1}(p)$ will explain why p is referred to as the risk. The risk is the probability that demand will be greater than the value t = o (p) as determined from a normal distribution.



Since p is a probability, it must be greater than zero but less than one. The solution of the risk equation is the first step in determining the depth of an item. As mentioned earlier, the risk parameter is set for each iteration and the cost, average requisition size and essentiality are known constants for each item. However, there is no guarantee that the solution of the risk equation will result

in a number in this range. Therefore, the value of p is constrained to be between 0 and 1.

After the risk p is determined, the normal distribution is used to determine the number t such that the probability that demand is greater than t is the risk. That is, $t=\phi^{-1}(p)$. The depth Z is determined from the equation

$$Z = AQD + SIGMA \times t$$

It should be noted that t can be either positive or negative. Thus depending on the risk allowed, t standard deviations of demand can either be added to or subtracted from the average quarterly demand in computing depth. This preliminary depth is then rounded and subjected to several restrictions to give the final load list quantity.

E. QUANTITY CONSTRAINTS

The primary constraint is the minimum quantity (one) specified by the range cut criterion. Other quantity restrictions are minimum, maximum, mandatory, and exclusion overrides applied to specific items. These are used to set upper or lower limits on the quantity to be carried or to specify a mandatory quantity. An exclusion override is a special case of the mandatory override in which the quantity is zero. Quantity overrides are usually identified prior to the running of the model. One of the more common overrides is a maximum quantity override specified by the fleet because of volume constraints. The next restiction is that no less than one dollar's worth of the item will be stocked. i.e. the quantity is increased such that the extended dollar value is greater than $1.00. Another restiction is that the change in the load-list quantity must exceed 25 percent before the load list will be adjusted to the new quantity. This is to eliminate the handling costs associated with small quantity changes. The new load-list quantity must also be in even multiples of the item's minimum replacement unit (MRU). The MRU reflects the minimum number of units

required to perform a task and may vary among APL's. The MRU for any item is the maximum of the MRU's appearing on the applicable APL's. Finally, for items without historical demand, the load list quantity is constrained to be less than 50 units and have an extended value less than $100. This constraint is designed to prevent the stocking of an excessive quantity or dollar value of an item based on an erroneous BRF estimate of demand.

F. EFFECTIVENESS PREDICTION

After the item quantity is determined, preliminary statistics concerning the item are accumulated. These statistics include a tally of the various overrides and restrictions applied, the method of estimating demand, and the extended dollar value of the item. The predicted quarterly demand quantity and frequency and the number of units and requisitions satisfied are also accumulated. These last statistics will be used to predict load list effectiveness after all candidate items have been processed. The number of units satisfied is estimated by assuming a normal distribution of demand to estimate the units short and subtracting this from the estimated average quarterly demand. The following formula is used to predict the units short:

$$\text{Units Short} = S\left[\phi\left(\frac{Z-U}{S}\right) - \left(\frac{Z-U}{S}\right)\Phi\left(\frac{Z-U}{S}\right)\right]$$

The predicted units short is constrained to be greater than zero, but less than or equal to the average quarterly demand, to prevent absurdities from entering the statistics. Similarly, requisitions satisfied is the difference between the quarterly demand frequency and the requisitions short. The requisitions short is computed by dividing the units short by the average requisition size.

After each candidate has been evaluated by the model to determine its load list quantity and the associated

statistics, a final computation of effectiveness is made. Net unit and requisition effectiveness are calculated by dividing the total units and requisitions satisfied by the total demand quantity and frequency, respectively, for load list items. Gross unit and requisition effectiveness are similarly computed except that non-load-list demands are also included. If the net requisition effectiveness meets the 85 percent goal then the optimal load list quantities have been determined. If requisition effectiveness is less than 85 percent then a new risk parameter smaller than the last λ is picked (i.e. less risk), and the model is rerun for all candidate items. If effectiveness is significantly more than 85 percent, then too much money is being spent for the desired effectiveness, and the load is reduced by picking a larger λ (i.e. more risk). Each successive run of the model is analyzed, and the risk parameter is changed until the predicted effectiveness is within tolerance of the desired effectiveness.

IV. ANALYSIS OF THE 1977 AD/AR TARSLL INVENTORY MODEL

A. THE BASIC TARSLL

The first step in analyzing the 1977 TARSLL was to develop the basic load list. A detailed flow chart of the TARSLL computer program obtained from FMSO was used to develop a FORTRAN program of the TARSLL model. In addition to the normal range, dollar value, and effectiveness statistics normally output, the program was modified to provide the distributions of essentiality, average quarterly demand (AQD), average requisition size (ARS), cost, and load list quantity. The input to this program was obtained from SPCC's files and included the parameter values and input tapes of the candidate items used to run the 1977 TARSLL. The results given in Appendix A were obtained from a run of the program. The load list range of 13,217 line items and value of $760,671 are comparable to the final 1977 TARSLL that went to the fleet. Of interest is the fact that no quantity overrides were applied to any items. Also the 85 percent effectiveness criterion was not met (see Figure 1). This presented no problem for this analysis since this TARSLL serves only as a baseline of comparison for other models. Another interesting feature of the output is the observation that the distributions of AQD, ARS, cost, and depth all decayed at an exponential or greater rate. To accomodate this the logarithms of the quantities were used for graphing purposes (see Appendix A). Other aspects of the output statistics will be discussed as they apply to different changes in the model.

Figure 1
1977 TARSLL

Predicted	ER	NER	TOTAL	ACTUAL
Net Unit	84.50	68.84	78.66	78.63
Gross Unit	71.21	58.08	66.32	59.18
Net Reqn	57.82	41.15	42.72	61.61
Gross Reqn	38.77	38.92	38.90	34.04

B. ACTUAL EFFECTIVENESS COMPUTATIONS

To determine the true effectiveness of the 1977 TARSLL, and to evaluate the effects of various changes to the model, 24 months of demand history from the MLSF data file were retrieved. The data was for the period October 1977 to September 1979, and included all of the demand data for the 5 currently active AD's and the only currently active AR in the Atlantic fleet. For the effectiveness computations the 24 months of data were divided into 22 consecutive overlapping quarters, i.e. September, October, November 1977 was the first quarter; October, November, December 1977 was the second quarter; November, December 1977, January 1978 was the third quarter; etc. Each of the six load list ships carried the same load, and no allowance was made for demand-based changes to the load list. The load list was considered to be 100 percent on board at the beginning of each quarter and was not resupplied during the quarter. This was done to simulate the 90 day wartime environment. Net and gross unit effectiveness and net and gross requisition effectiveness were computed for each of the 22 quarters for each tender or repair ship. These were then averaged to give the fleet effectiveness by quarter. Unit effectiveness is the simple average of the number of units satisfied by a tender or repair ship in a three month period divided by the number of units demanded in the same period. For net effectiveness, only demands for items on the TARSLL are included in the computations, whereas for gross effectiveness all demands are counted. In computing requisition effectiveness, each data element is considered a requisition, and a requisition which is only partially filled is considered not filled. Requisition effectiveness is then computed as the ratio of requisitions filled divided by the total requisitions in a three month period.

The first item of interest to be examined in the output of the historical effectiveness computations (see Appendix B) was the relative effectiveness of the load list on the five tenders and one repair ship. No single tender was better or worse across all four measures of effectiveness than the other tenders. The repair ship, however, was worse in all measures than each tender, averaging about ten percent below the mean. Even so, the total variation in effectiveness was small. The standard deviation was less than 3 percent for net effectiveness and less than 5 percent for gross effectiveness. These results held for all effectiveness computations for all variations of the TARSLL model. Therefore only the fleet-wide summary statistics will be used in subsequent comparisons of different models.

The effectiveness results were also examined to see if there was a serious degradation in effectiveness over time. It was obvious that some degradation was occurring over the two-year period, but the amount was less than 5 percent across all measures of effectiveness (see Appendix B). This indicates that the current policy of developing a new TARSLL every 3 years is adequate to provide the desired performance.

The last analysis considered the interrelationships among the four measures of effectiveness, and the relationship between the predictions made by the TARSLL program and the four actual measures of effectiveness. As expected, the net effectiveness measures were significantly higher than the gross effectiveness measures, and unit effectiveness was better than requisition effectiveness. All of the effectiveness measures were within 5 percentage points of the predicted values except net requisition effectiveness (see Figure 1). These results were not too surprising although the actual net unit effectiveness was closer to the predicted value than had been expected, based

on the type commander's comments. The closeness of the predicted and actual effectiveness measures indicates that the composition of the 1977-1979 data is similar to the two years (1975-1976) of data used to develop the TARSLL. The big surprise was the size of the difference between actual and predicted net requisition effectiveness. The difference of almost 20 percentage points indicates that net requisition effectiveness may not be a good goal for the model. This will be investigated further as different models are applied.

C. ESSENTIALITY DETERMINATION

The first change to the model to be investigated concerns the determination of essentiality. As described previously, the 1977 TARSLL used the AQD for essentiality for all items with a demand history and used an essentiality factor between 0 and 1 computed from the Military Essentiality Codes for all other items. The proposed change is to use the predicted AQD as the measure of essentiality for all items. Since the BRF method was not considered as reliable an estimate of future demand as historical data, a larger risk of stockout was allowed for items without historical demand. This was accomplished by using the smaller essentiality factor computed from the MEC's. Because essentiality appears in the denominator of the risk equation, a decrease in its value increases the risk of stockout. An analysis of the MLSF data (see Appendix C) reveals, however, that for the majority of the items, historical demand may be no better an estimate of future demand than the BRF computation. Almost half of the MLSF items appeared only once, and 77 percent appeared 3 times or less. This low demand frequency over a two year period makes the problem of predicting the number of demands in a period very difficult. With the increased confidence in the BRF recently shown by SPCC, the essentiality factor was changed

to the AQD for all candidate items for the 1980 TARSLL. This increased the essentiality for items without historical demand from an average value of .67 (see Appendix A) to over 1.5 (forced by the range cut). The resulting decrease in risk will increase the depth of items with high predicted demand and reduce the number of maximum risk constrained items. The result should be increased net effectiveness. When this change is made to the model, the cost of ER items increases from $375,744 to $435,236, and the distribution of the depth of the load list items shifts upward (see Appendix D). The number of ER items with a maximum risk constraint decreased from 2778 to 1863, but the number of minimum risk constrained items increased from 1237 to 2899, confirming the general risk shift due to the essentiality change. A total of 22,792 units were added. The predicted unit effectiveness showed modest increases of 3 to 5 percent (see Figure 2). Requisition effectiveness, however, showed large gains, with net requisition effectiveness increasing dramatically. Of course the key question is whether the actual effectiveness showed a corresponding increase. Unfortunately this was not the case, as all four of the effectiveness measures increased only slightly. 1Thus the small increase in depth and dollar cost from this change does not significantly improve actual effectiveness. It does, however, bring the requisition effectiveness predictions much closer to the actual figures.

Figure 2

	1977 TARSLL		E = AQD	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	83.77	78.69
Gross Unit	66.32	59.17	69.99	59.21
Net Reqn	42.72	61.61	71.78	62.05
Gross Reqn	38.90	34.02	62.31	34.25

D. IMPACT OF THE K3 FACTOR

The next change to be investigated was the change of the K3 factor from .33 to .6. K3 is used in the BRF method of computing AQD to indicate the percent of items installable

at no lower than the tender level that are likely to be installed by a tender or repair ship. The value of .33 was chosen when tenders and repair ships had separate load lists. Since tenders are one of three activities (tenders, repair ships, and shipyards) that can install the part, the likelyhood is .33 that it would install the part. With the introduction to the fleet of larger and more capable tenders, most of the repair ships were decommissioned, and their share of the workload was split between the tenders and shipyards. The reduction in repair ships also brought about a merger of the AD and AR load lists. When this happened, though, the likelihood value of .33 was not changed. The new value of .6 for K3 is designed to represent this merger of the AD and AR TARSLL's and the new split in workload between tenders and shipyards. This change to the model, however, is more of a theoretical purification than an actual substantive change. The change resulted in a small increase in the number of units carried, and a corresponding increase of only $6000 in total load list cost (see Appendix E). The predicted effectiveness dropped slightly across all measures of effectiveness, and actual effectiveness remained about the same (see Figure 3). This is due to the higher demand predicted for most ER items. Again, there was a large disparity of over 20 percentage points between predicted and actual net requisition effectiveness.

Figure 3

	1977 TARSLL		MODEL WITH K3=.6	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	77.66	78.63
Gross Unit	66.32	59.17	65.57	59.18
Net Reqn	42.72	61.61	39.83	61.61
Gross Reqn	38.90	34.02	36.56	34.04

E. RANGE DETERMINATION

The range cut had the greatest affect on the TARSLL. Without changing this factor there can be no change in the line items being carried. The Commander, Naval Surface Forces Atlantic Fleet has specified the number of line items

to be about 15,000. This number is derived based on past experience to provide an adequate balance between the range of items carried and the number of items that have no demand. This is also used to meet the volume constraints aboard the tenders and repair ships. The range-cut factor used in the development of the 1977 AD/AR TARSLL was 12. This means that an item had to have predicted demand of 12 units in eight quarters to be carried. This is equivalent to an AQD of 1.5. Less than 7 percent of the ER and 25 percent of the NER items satisfied this very restrictive criterion. The two options of interest are 1) a range cut of 4 (AQD=.5); and 2) no range cut. The range cut of 4 has been suggested for the 1980 TARSLL, and the "no-range-cut" option is used for FBM submarine tenders.

Because a range cut of 4 forces onto the load list any item with an AQD greater than 0.5, the number of line items carried nearly doubled to a total of 25,226 items, with 12,215 of these at a depth of one. The distribution of depth was essentially unchanged above 10 units, with the total number of units increasing only 7 percent (see Appendix F). The total cost of the load list also doubled to over $1.5 million. Interestingly, over 85 percent of the increase in both line items and cost came from ER items, with two-thirds of those using the BRF method of predicting demand (see Appendix D). The results of the effectiveness predictions were interesting because net unit effectiveness decreased while net requisition effectiveness increased (see Figure 4), indicating that the unit effectiveness for the added items was less than for those in the base TARSLL, but that the average requisition sizes were smaller and yielded better requisition effectiveness. As was expected, both gross unit and gross requisition effectiveness increased slightly. Even more interesting were the results of the actual effectiveness computations. The gross effectiveness

measures both increased slightly but the net effectiveness measures both decreased slightly (see Figure 4). Therefore, this range cut does not seem justified.

Figure 4

	1977 TARSLL		RC = 4	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	77.65	77.28
Gross Unit	66.32	59.17	68.17	59.69
Net Reqn	42.72	61.61	45.07	38.01
Gross Reqn	38.90	34.02	36.56	34.04

There are two aspects of the no-range-cut option that affect the load list. The first is that items are not required to have a minimum predicted AQD to be considered by the model as candidates for inclusion in the load list. The second, and perhaps more important, fact is that no items are forced on the load list. The results of eliminating the range cut are startling. A total of 19,915 items are carried on this load list. The number of ER items nearly doubled, but the number of NER items dropped by over a third. The depth of the line items carried also showed a significant increase with less than half of the number of items stocked at the level of one. All other depths less than 10 had large increases, but above 10 units there was very little change. This resulted in only a 13 percent increase in the total number of units carried. The greatest change was in the cost of the load list. Despite the large increase in the number of items carried, the dollar value was half that of the base TARSLL (see Appendix G). The predicted effectiveness improved significantly with net requisition effectiveness nearly doubling. Actual effectiveness gains were not so dramatic. Net requisition effectiveness was the only measure which had an increase over 3 percentage points (see Figure 5). That net requisition effectiveness went from a value considerably below actual effectiveness in the base TARSLL to a value slightly above actual in the no-range-cut load list is particularly noteworthy. This again points to the unreliability of predicted net requisition effectiveness as

a measure of actual load list effectiveness. Thus, despite the large number of line items carried, the no-range-cut option deserves further investigation because it produces generally better effectiveness at a much lower cost.

Figure 5

	1977 TARSLL		MODEL WITH RC=0	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	90.86	81.37
Gross Unit	66.32	59.17	67.90	59.28
Net Reqn	42.72	61.61	80.69	76.14
Gross Reqn	38.90	34.02	65.55	32.40

A simple modification to the no-range-cut option would be the addition of a constraint that requires an item have an AQD of at least 0.5 in order to be carried. This is essentially equivalent to requiring a range cut of four except that no items would be forced on the load list, since the items with an AQD less than 0.5 would be the only items eliminated from consideration, the results of this modification should be a general reduction in the number of line items carried without a significant reduction in effectiveness. This is in fact what happens (see Appendix H). The number of line items drops to 13,477, just slightly more than the base TARSLL number. The greatest decrease is in the number of items with a depth of one or two from 4505 to 2251 line items. The total number of units also drops to only 5.3 percent above the base TARSLL. The total load-list cost drops only slightly to $366,755, but is still less than half the cost of the base TARSLL. A quick look at the cost distributions for these two load lists explains the difference. The cost of about 72 percent of the items on the 1977 TARSLL was less than five dollars each, but the rest of the items ranged to a maximum of $34,780, including 85 items over $600 each. In contrast, over 97 percent of this modified no-range-cut load list had a cost of less than five dollars and no item cost more than $286. In comparison to the no-range-cut option, the predicted effectiveness drops slightly but actual effectiveness remains about the same In

comparison to the basic TARSLL model with a range cut of 12, this load list has about the same number of line items and total units at less than half the cost, yet with generally better effectiveness (see Figure 6). Therefore this range cut modification appears to be a significant improvement over the current range cut procedure.

Figure 6

	1977 TARSLL		MODIFIED RC=0 MODEL	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	90.82	81.76
Gross Unit	66.32	59.17	67.34	59.11
Net Reqn	42.72	61.61	79.62	76.62
Gross Reqn	38.90	34.02	63.68	31.70

F. EFFECTIVENESS CRITERIA

As noted previously, the predicted net requisition effectiveness can fluctuate widely without corresponding fluctuations in the actual net requisition effectiveness. A similar but more stable measure of effectiveness is the net unit effectiveness. This measure did not vary as much throughout the many changes, and its predicted and actual values were fairly close. Net unit effectiveness also has an intuitive appeal. Since tender peacetime industrial work often involves the overhaul of equipment, more units of a line item may be used than would be necessary for the basic repair job that would be accomplished in a wartime environment. Also, the wide variances in the distribution of average requisition size for the MLSF demand data (see Appendix B) indicate that one requisition may not be used for only one job. Although half of the items have an ARS of 5 units or less, over 85 units have an ARS greater than 600 units and one item has an ARS of 25,250 units. Thus unit effectiveness may be a better indicator of load list performance. A change in the performance measure, however, necessitates a change in the mathematical model. In the basic TARSLL model the risk equation is

$$p = \lambda CA/E$$

The "A" or average requisition size appears in the equation

because of the constraint of 85 percent net requisition effectiveness. With the change to the unit effectiveness measure, A disappears. This is the same as setting A=1 for all items, which is done for those items that use the BRF computation to estimate demand. Therefore this change only affects the depth of those items with historical data based demand predictions. Setting A=1 for the depth computation will reduce the risk and correspondingly increase the depth on those items. The result is a large increase in the depth and cost of these items. The number of units carried jumps to 815,202 and the cost increases by $640,000 to over $1.4 million (see Appendix I). Actual and predicted effectiveness increased for all four effectiveness measures. The largest increase was found in actual net requisition effectiveness which increased over 15 percentage points (see Figure 7). Thus a change in the measure of effectiveness to net unit effectiveness results in a significant improvement in all effectiveness measures, but at a correspondingly large increase in cost.

Figure 7

	1977 TARSLL		MODEL WITH A=1	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	89.01	84.68
Gross Unit	66.32	59.17	75.01	63.64
Net Reqn	42.72	61.61	46.63	76.11
Gross Reqn	38.90	34.02	42.46	41.93

V. ALTERNATIVE MODELS

A. MODIFIED 1980 TARSLL MODEL

As mentioned previously, several changes have been incorporated into the 1980 TARSLL model. These are the use of AQD as the measure of essentiality, K3 equal to .6, and a range cut of 4. To determine their cumulative effect, these changes were incorporated into the 1977 TARSLL model. The range cut criterion was modified so that items passing the range cut were not forced onto the load list. This was done because, as discussed in chapter 4, the normal range cut procedure would have resulted in a range of over 25,000 line items, far exceeding the 15,000 line item target set by the type commander. This model results in a load list with 15,166 line items at a cost of $444,311 (see Appendix J). This 40 percent cost reduction from the 1977 TARSLL was achieved despite a 10 percent increase in the total units carried by eliminating any item with a unit cost over $286. The cost distribution for this model is nearly identical to the modified no-range-cut model. As expected there are large increases in both predicted and actual effectiveness (see Figure 8). The predicted effectiveness results were better than the results obtained when each of the three changes was implemented separately. The results of the actual effectiveness computations were similar to the modified no-range-cut results. This is not surprising since the only one of the three changes that had a significant impact on actual effectiveness was the range cut change. In light of

Figure 8

	1977 TARSLL		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	78.66	78.63	91.76	81.73
Gross Unit	66.32	59.17	71.18	59.17
Net Reqn	42.72	61.61	88.40	76.70
Gross Reqn	38.90	34.02	70.87	32.07

the improved net effectiveness and the significantly lower cost of this model, the changes appear warranted.

B. FBM SUBMARINE TENDER MODEL

Tenders supporting FBM submarines (AS-FBM) use a model that is slightly different from the 1977 TARSLL model. Two differences that have already been discussed are the use of AQD for determining essentiality, and the use of no range cut. A third difference is the use of the Poisson distribution to represent demand for items with a low AQD. The Poisson distribution is commonly used in inventory models to represent independent demands occurring at a constant rate. In inventory situations at SPCC, the Poisson distribution is only used up to a demand of 10 units because of the computational problems resulting from the iterative process used to determine the probability of demand. Above 10 units the normal distribution is used with the central limit theorem offered as justification. The no-range-cut procedure was modified to allow for consideration only of items with AQD greater than 0.5. This is the same modification that produced significant improvement in the 1977 TARSLL. It also results in the same range-cut criterion that was used in the 1980 TARSLL model examined above. This makes analysis of the effects of the Poisson distribution easier, since now the only difference between the AS-FBM model and the 1980 TARSLL model discussed above is the use of the Poisson distribution. The use of the Poisson distribution produced unusual results (see Appendix K). Compared to the 1980 TARSLL, the AS-FBM model had a significant increase in the number of line items to 16,225. The total number of units, however, decreased slightly to 685,010. This was due predominantly to a substantial reduction in the number of items with a depth of between 20 and 40 units, and an increase in the number of items with a

depth of up to five units. Despite the decrease in total units, the load list cost increased by 25 percent. This resulted from carrying many more high priced items, including one that cost $34,780. The effectiveness predictions improved slightly in all areas except net unit effectiveness, which remained essentially the same (see Figure 9). Actual effectiveness, however, had the reverse trend. Gross requisition effectiveness , which had the largest predicted increase of nearly 5 percentage points, was the only measure to show an increase in actual effectiveness. The greatest decline was the over 5 percentage point drop experienced by net requisition effectiveness, which indicates that the predictions obtained using the Poisson distribution are misleading and do not represent the demand as well as the normal distribution. Thus, despite higher cost, this model does not perform as well as the modified 1980 TARSLL.

Figure 9

	AS-FBM MODEL		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	91.75	80.04	91.76	81.73
Gross Unit	73.08	58.96	71.18	59.17
Net Reqn	90.02	69.03	88.40	76.70
Gross Reqn	75.59	32.79	70.87	32.07

C. GAMMA DISTRIBUTION MODEL

An alternative distribution that has greater flexibility in fitting empirical distribution curves is the gamma distribution. Using this distribution in the 1980 TARSLL model has a major impact on the size, cost, and effectiveness of the load list (see Appendix L). The number of line items carried is reduced to 13,704 and the total number of items carried is reduced to 616.616. Correspondingly, the dollar value of the load list is reduced to $330,514. Unfortunately, the predicted and actual effectiveness measures are also significantly lower than the 1980 TARSLL effectiveness values (see Figure 10). Thus the gamma distribution does not appear to provide significantly

better results than the normal distribution. The gamma distribution is also more difficult to implement, increasing the computer time required to generate the load list by nearly 50 percent.

Figure 10

	MODEL WITH GAMMA DIST		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	81.31	77.13	91.76	81.73
Gross Unit	63.56	56.17	71.18	59.17
Net Reqn	78.10	68.13	88.40	76.70
Gross Reqn	63.05	29.09	70.87	32.07

One reason why neither the Poisson nor the gamma distribution improves the load-list effectiveness may be that the distribution is being fit to the wrong data. The constraint on the basic TARSLL model is net requisition effectiveness of 85 percent. However, the distributions are being applied to the unit demand. The ARS factor is then applied to convert the unit demand data to requisition demand data. The proper procedure would be to fit the distribution to the actual demand frequency data. An alternative to this is to use a model that has unit effectivenes as its objective.

D. UNITS SATISFIED MODEL

A completely different approach to the model is to maximize the unit demand satisfied, subject to a budget constraint. Since there is no formal budget constraint on the AD/AR TARSLL, the value (K) of the modified 1980 TARSLL is chosen for comparison purposes. This model can be expressed mathematically as:

$$\text{Maximize} \quad \sum_{i=1}^{n} Ui - Vi$$

$$\text{Subject to} \quad \sum_{i=1}^{n} Ci\ Zi \leq K$$

As with the basic TARSLL model, this problem is solved using a Lagrange multiplier approach. Assuming a normal distribution for demand, the following equations are obtained:

$$1.\ Zi = Ui + \Phi^{-1}(\theta \cdot Ci)\, Si$$

$$2.\ \sum_{i=1}^{n} Ci \cdot Zi \leq K$$

Equations 1. and 2. must be solved simultaneously for Zi and 0. This leads to the same iterative solution procedure used for the basic TARSLL. The only difference is that now the risk equation is $p=\lambda C$ where $\lambda=\theta$. The "A" term has dropped out of the TARSLL risk equation because units, not requisitions, satisfied is being maximized. Similarly, the "E" term has been deleted because there is no essentiality weighting, i.e. one unit demand satisfied is as good as another. If unit effectiveness were maximized, the only difference would be a constant term representing the total demand. The same results could have been obtained by starting with the objective function to minimize total load list cost, subject to the constraint that net unit effectiveness be greater than 85 percent. For comparison purposes, this model was implemented by changing the risk equation in the 1980 TARSLL model above to $p=\lambda \cdot C$ and rerunning the program. For want of anything better, the value of the risk parameter was not changed even though the two parameters do not have the same interpretation. As expected, the results were not optimal. The cost of this load list was less than two-thirds the cost of the modified 1980 TARSLL (see Appendix M). Even so, predicted and actual effectiveness were not much worse than the 1980 TARSLL (see Figure 11). Each of the actual unit effectiveness measures was only about one percentage point lower. The seven percentage point shortfall in each of the requisition effectiveness measures caused a little more concern, but the outlook for significant gains was encouraging. There was one major drawback, however: the load list range of 16,382 items was already considerably above the 15,000 goal set for the TARSLL, and the total units of 711,678 was only slightly

less than the number on the 1980 TARSLL. Therefore, despite its significantly lower cost, this alternative did not satisfy the type commander's criteria as well as the modified 1980 TARSLL model.

Figure 11

	UNITS SAT MODEL		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	90.12	80.52	91.76	81.73
Gross Unit	68.05	58.47	71.18	59.17
Net Reqn	79.85	69.58	88.40	76.70
Gross Reqn	63.54	25.97	70.87	32.07

E. UNIT EFFECTIVENESS MODEL

The last alternative to be explored was the application of the net unit effectiveness measure to the modified 1980 TARSLL model. As described in chapter 4, the use of the unit effectiveness measure requires setting A=1 in the risk equation. When this is done, and the program rerun, impressive increases compared to the base 1980 TARSLL are obtained in both predicted and actual effectiveness (see Figure 12). It should be noted that these actual effectiveness results are similar to those obtained when this change is made to the 1977 TARSLL model. These effectiveness improvements are accompanied by a significant increase in the size and dollar value of the load list (see Appendix N). At 17,792 line items and 885,655 total units, this alternative load list is much larger than either the 1977 unit effectiveness load list or the basic 1980 TARSLL. The cost of $1.1 million is over 20 percent less than the cost of the comparable 1977 model, but is still over twice the cost of the 1980 TARSLL.

Figure 12

	Unit Effectiveness		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	96.95	84.46	91.76	81.73
Gross Unit	80.53	63.90	71.18	59.17
Net Reqn	90.13	81.43	88.40	76.70
Gross Reqn	76.51	41.44	70.87	32.07

An interesting question is whether the large increases in the number of items and the dollar value are required to obtain the additional effectiveness. To answer this question

the unit effectiveness modification to the 1980 TARSLL was rerun with a larger risk parameter. The result was a significant reduction in the number of line items to only 9271, but the total number of units decrease only slightly to 764,941 (see Appendix O). This was caused by the elimination of a large number of items with a depth of one or two. Although the load-list cost is reduced by over 50 percent to $465,605, it is still slightly more than the cost of the 1980 TARSLL. Actual effectiveness decreases, however, were minimal (see Figure 13). Thus this model provides significantly better net effectiveness than the 1980 TARSLL model at only a slight increase in cost.

Figure 13

	Unit Effectiveness		1980 TARSLL	
	Predicted	Actual	Predicted	Actual
Net Unit	94.54	84.06	91.76	81.73
Gross Unit	70.83	60.18	71.18	59.17
Net Reqn	80.73	77.98	88.40	76.70
Gross Reqn	57.55	25.54	70.87	32.07

VI. CONCLUSIONS AND RECOMMENDATIONS

The foregoing analysis of the 1977 AD/AR TARSLL examined the mathematics of the load list model and investigated proposed changes to the model. The conclusions to be drawn from this analysis can only be made with respect to the 1977 AD/AR TARSLL. Recommendations to implement certain of these changes on the 1980 and subsequent AD/AR TARSLL's are based on the conclusion that the demand data base is reasonably stable. This was evident from the minimal degradation of effectiveness over the two years of demand data and the closeness of predicted and actual effectiveness computations. This stability also justifies the creation of a new load list every three years.

The change to the use of the AQD as the measure of essentiality for all items has a marginal impact on the 1977 AD/AR TARSLL. There was a modest increase in the size and dollar value of the load list. This was accompanied by an increase of less than one percentage point in each of the four actual effectiveness measures. The increase in the K3 factor from .33 to .6 has minimal impact on the load-list size, cost and effectiveness. Although the change is merely a theoretical purification of the TARSLL process it is justified. The current range-cut process is too restrictive and reduces the effectiveness of the mathematical inventory model. The proposed range cut of four demands in two years produces a load list that is twice as large and expensive as the 1977 TARSLL. However, even with these increases, net effectiveness decreases. Elimination of the range cut provides significant improvements in cost and effectiveness, but the range of the load list is too large. Adding the criterion that predicted demand must exceed four demands in two years for an item to be considered by the model reduces

the load list to the desired size, without significantly affecting effectiveness. The implementation of the essentiality, K3 factor, and range cut changes into the 1977 AD/AR TARSLL resulted in dramatic improvements. The net effectiveness measures improved significantly, while the cost was reduced by 40 percent. Therefore, these changes should be implemented in the 1980 AD/AR TARSLL.

The use of different distributions to represent demand did not result in any major improvements over the use of the normal distribution. The use of the Poisson distribution produced a larger and more costly load list with lower actual effectiveness. The gamma distribution produced a load list with lower cost, but also with correspondingly lower effectiveness. Without major improvements in either cost or effectiveness, the ease of application of the normal distribution makes its use preferable. Therefore, the continued use of the normal distribution is recommended for the 1980 AD/AR TARSLL.

The two basic changes to the model itself were both promising. The units-satisfied model had a lower cost than the 1980 TARSLL model, but its effectiveness was not as good, and the number of line items already exceeded the goal of the type commander. The total number of units, however, was less than the total units on the 1980 TARSLL model. The unit effectiveness model had exactly the reverse situation. It had a low number of units, but a high total unit count. Consequently, it had a higher cost than the 1980 TARSLL. It also had better actual effectiveness. The unit effectiveness model is preferable because of the fewer number of line items. It should be considered as a replacement for the current AD/AR TARSLL model.

APPENDIX A

1977 AD/AR TARSLL STATISTICS

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                     TARSLL LOAD LIST OUTPUT STATISTICS

     LE =  0.154   LN =  0.154   T =  1.0   K13 = 1.

                                          NFR           FR          TOTAL
CANDIDATES                              14567       139691        154258
LL RANGE                                 3557         9660         13217
LL VALUE                              384927.      375744.       760671.
ADDS TO LL                               3557         9660         13217
ADDS VALUE                            384927.      375744.       760671.
DELETES FM LL                               0            0             0
DELETES VALUE                              0.           0.            0.
FORCED ON LL                             1540         3196          4736
CONSTRAINED QTY                             0          647           647

          EFFECTIVENESS DATA
UNITS SAT                             130451.       63167.       193618.
REQN SAT                                2050.       14085.        16135.
DMD   LL                              154380.       91755.       246135.
      NLL                              28607.       17011.        45618.
      ALL                                                        291753.
FREQ  LL                                3546.       34226.        37772.
      NLL                               1742.        1963.         3705.
      ALL                                                         41477.
NET UNIT EFF                           0.8450       0.6884        0.7866
GROSS UNIT EFF                         0.7121       0.5808        0.6632
NET REQN EFF                           0.5781       0.4115        0.4272
GROSS REQN EFF                         0.3877       0.3892        0.3890

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                        3557         4150          7707
               NLL                       9926         9040         18966
               ALL                                                 26673
BRF X POP      LL                           0         5510          5510
               NLL                          0       107747        107747
               ALL                                                113257
FORCED FCST    LL                           0            0             0
               NLL                       1084        13244         14328
               ALL                                                 14328

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                           1345         2778          4123
            NLL                             0            0             0
            ALL                                                     4123
MIN RISK    LL                            166         1237          1403
            NLL                             0            0             0
            ALL                                                     1403

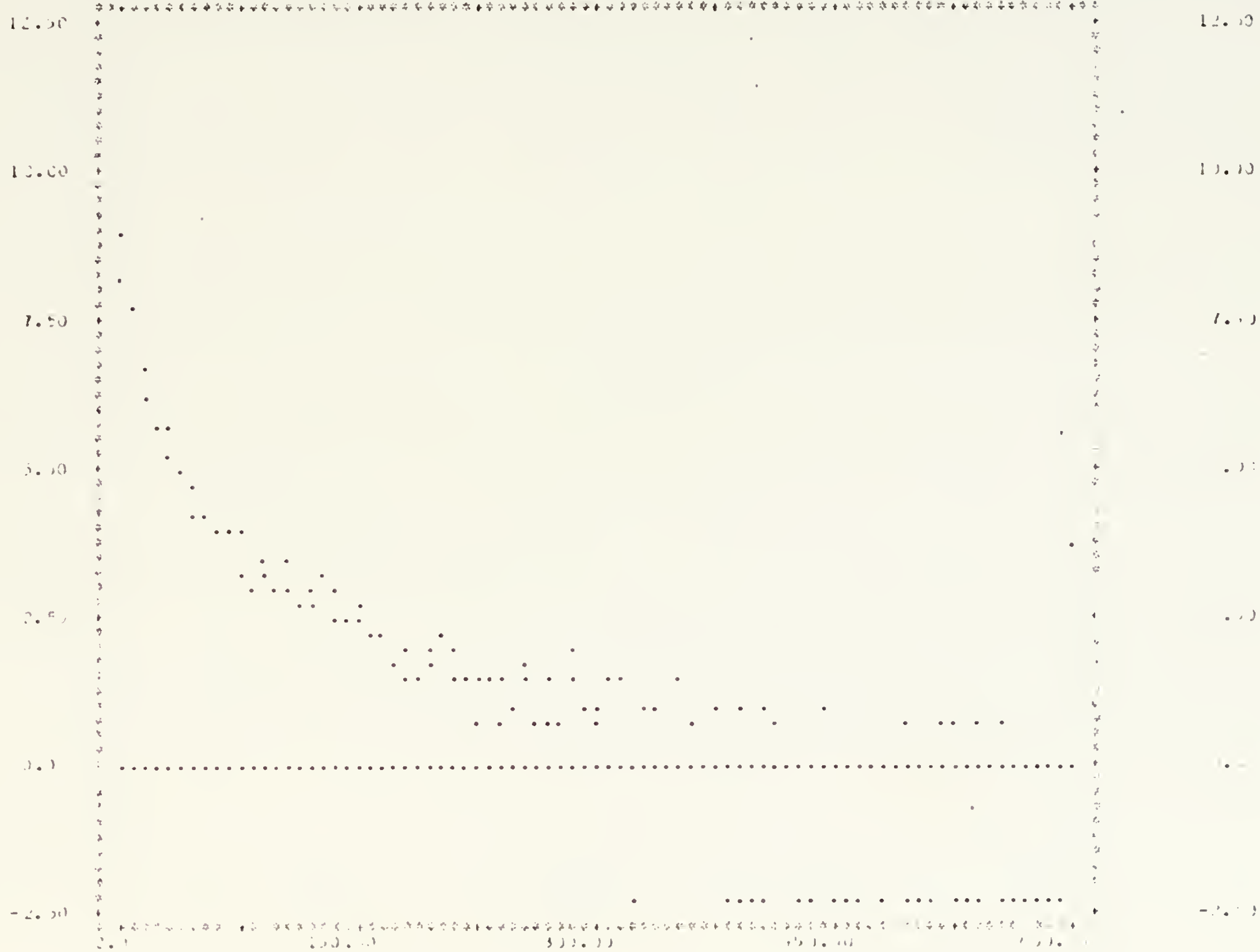
          OVERRIDES APPLIED
MANDATORY                                   0            0             0
MAX QTY                                     0            0             0
MIN QTY                                     0            0             0
DELETE                                      0            0             0
```

1977 AD/AR TARSLL STATISTICS

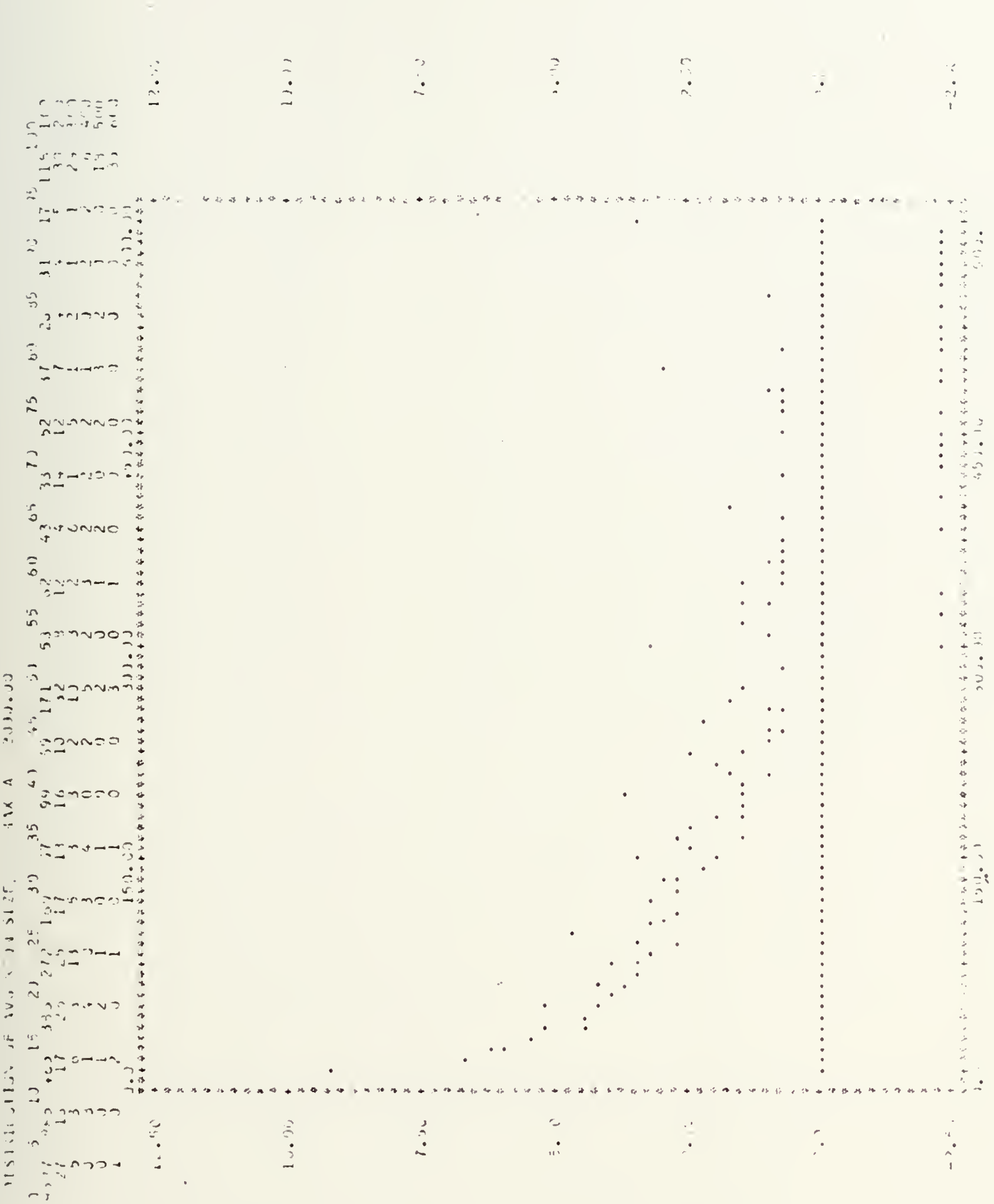
```
DISTRIBUTION OF ESSENTIALITY
0     .05   .10   .15   .20   .25   .30   .35   .40   .45   .50   .55   .60   .65   .70   .75   .80   .85   .90   .95   1.0
 230   17     9    15    12    14     6     9     4    17    15    40     3 4597    47    26    13    16    12   431

DISTRIBUTION OF AVG QUARTERLY DEMAND      MAX AQD  10318.00

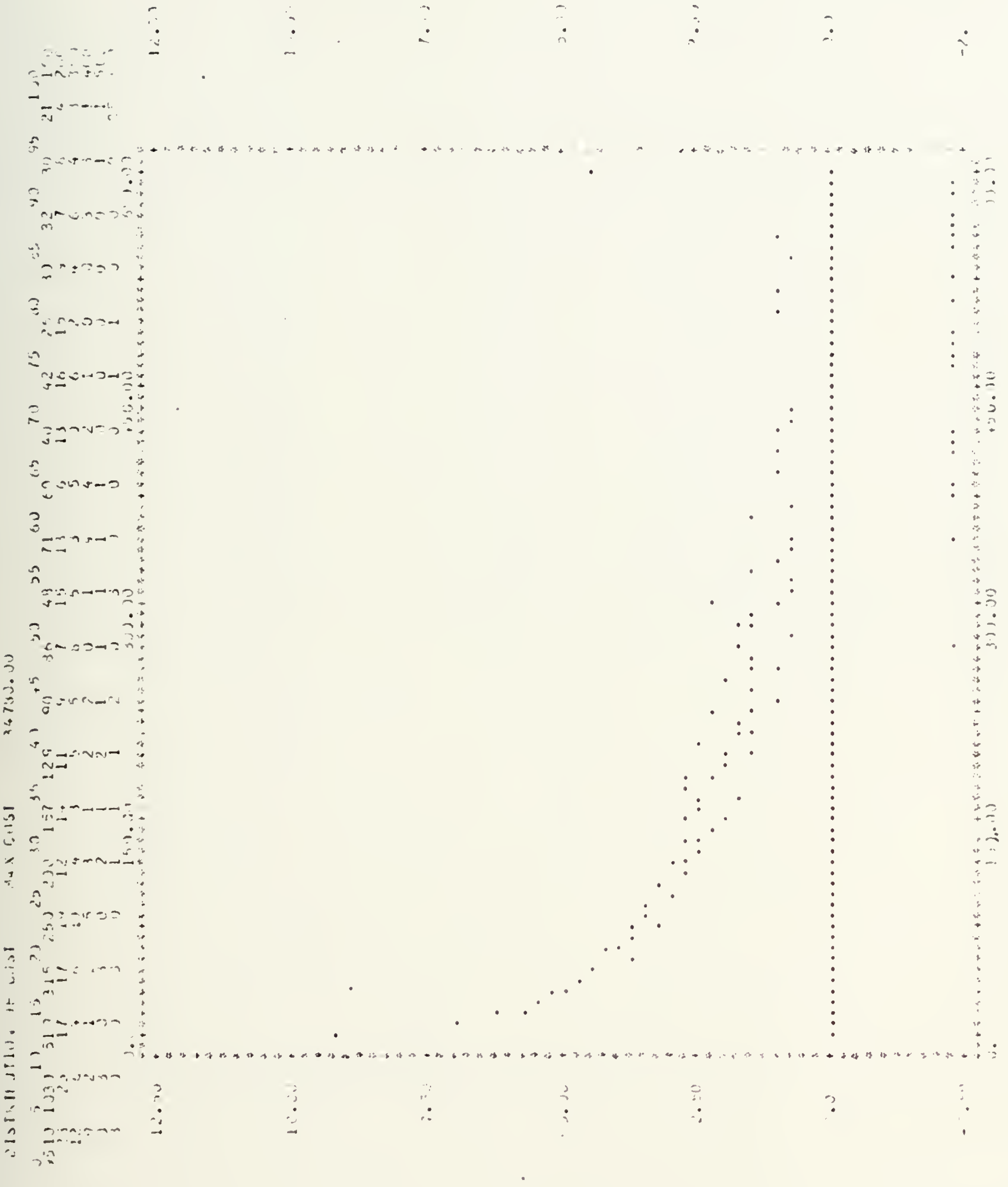
0      5     10    15    20    25    30    35    40    45    50    55    60    65    70    75    80    85    90    95    100
7432. 2320   947   557   344   242   175   139   113    71    77    56    59    61    26    51    20    31    23    20  [illegible]
  41    20    17    12    14    27    16    13    13    11    14     8    12    10     6     3     5     4     4     7  [illegible]
   6     1     [illegible]  5  [illegible] [illegible]  6  2   4     4     5     6 [illegible] 2  4     2     3 [illegible] [illegible] 2 [illegible]
   3     5     4 [illegible] 0     3     5     3     1     1     4     1     2     1     3 [illegible] 0  3 [illegible] [illegible] 400
   3     0     2     1     1     0     0     0     3     1     0     0     1     0     1     0     0     1     2     0    500
   0     1     6     2     0 [illegible] 0     0     2     1     0     2     0     0     0     0     0     1     0    44    600
```



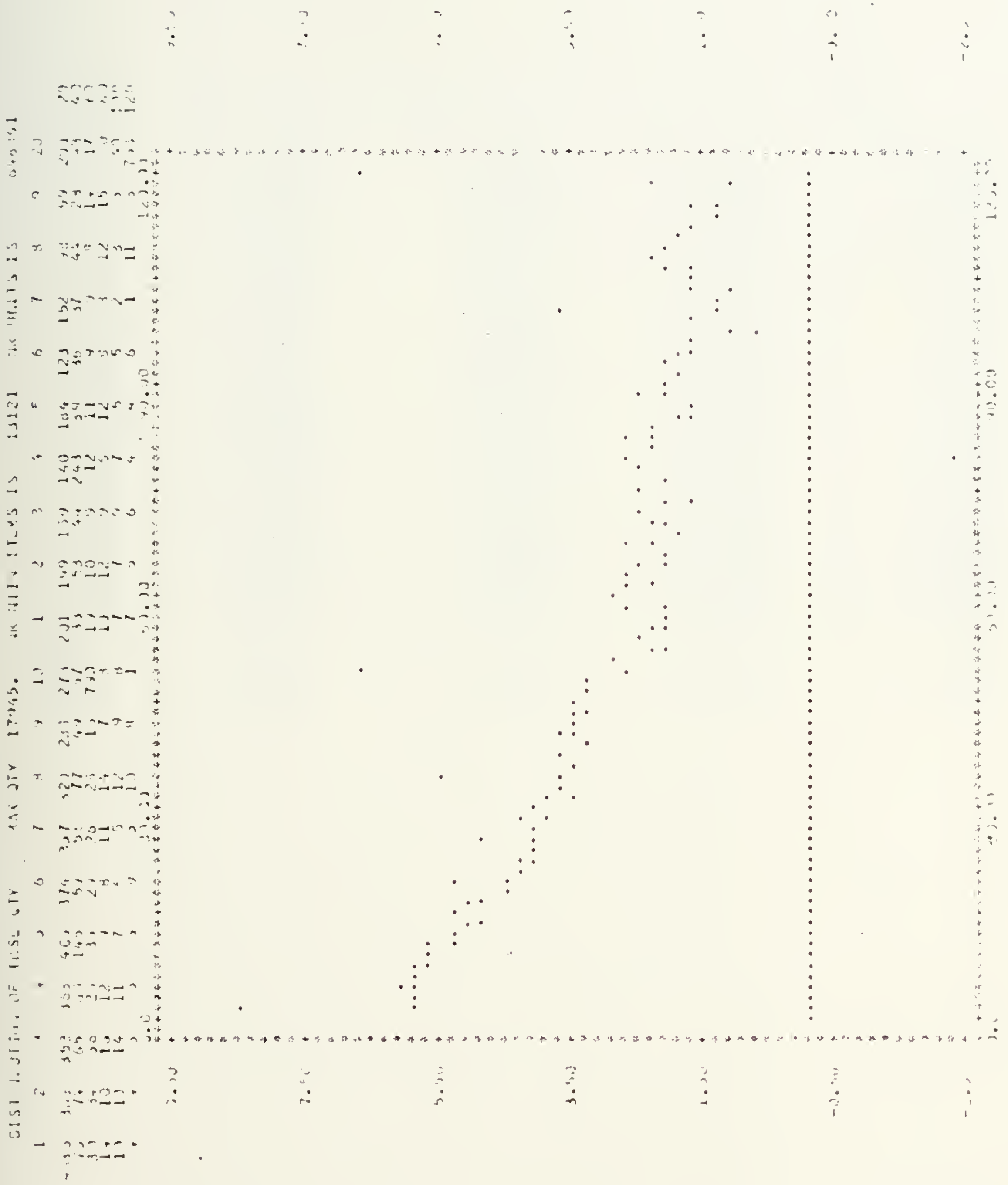
1977 AD/AR TARSLL STATISTICS



1977 AD/AR TARSLL STATISTICS



1977 AD/AR TARSLL STATISTICS



APPENDIX B

1977 AD/AR TARSLL EFFECTIVENESS

LOAD LIST EFFECTIVENESS ATLANTIC FLEET

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.8009	0.5964	0.6634	0.3763
2	0.8072	0.6053	0.6356	0.3600
3	0.8196	0.6217	0.6390	0.3753
4	0.8066	0.6279	0.6402	0.3947
5	0.8297	0.6577	0.6368	0.4036
6	0.8009	0.6286	0.6119	0.3933
7	0.7950	0.6204	0.6177	0.3385
8	0.8077	0.6538	0.6501	0.4076
9	0.7952	0.6517	0.6605	0.3958
10	0.7659	0.5773	0.6364	0.3648
11	0.7536	0.5378	0.6214	0.3419
12	0.7554	0.5400	0.6218	0.3392
13	0.7980	0.6098	0.6293	0.3340
14	0.7593	0.5679	0.6031	0.3111
15	0.7762	0.5208	0.5870	0.2879
16	0.7652	0.5253	0.5832	0.2621
17	0.7594	0.5141	0.5842	0.2775
18	0.7753	0.5776	0.5896	0.2793
19	0.8042	0.6025	0.5964	0.2893
20	0.7996	0.6057	0.6084	0.2976
21	0.7601	0.5856	0.5853	0.2996
22	0.7497	0.5656	0.5515	0.2833
MEAN	0.7863	0.5917	0.6161	0.3462
S.DEV	0.0235	0.0434	0.0288	0.0474

1977 AD/AR TARSLL EFFECTIVENESS

LOAD LIST EFFECTIVENESS AD 17

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.9415	0.6974	0.7731	0.3866
2	0.9065	0.7444	0.7306	0.3770
3	0.7638	0.6004	0.7293	0.4235
4	0.7655	0.6132	0.6973	0.4316
5	0.7151	0.5369	0.7044	0.4415
6	0.7268	0.5276	0.6383	0.3860
7	0.7444	0.5373	0.7059	0.4280
8	0.7124	0.6185	0.7355	0.4818
9	0.7733	0.5963	0.7750	0.4600
10	0.7983	0.6018	0.7548	0.4291
11	0.8350	0.6400	0.7412	0.4206
12	0.8194	0.6393	0.7204	0.4239
13	0.8195	0.6652	0.7136	0.4073
14	0.7980	0.4984	0.6931	0.3671
15	0.7680	0.2122	0.6248	0.2916
16	0.7901	0.2939	0.6226	0.2867
17	0.7956	0.3258	0.5966	0.2578
18	0.8232	0.5836	0.6311	0.2743
19	0.7949	0.5532	0.5980	0.2674
20	0.7434	0.5628	0.5916	0.2333
21	0.7165	0.5167	0.5735	0.2683
22	0.6976	0.5293	0.5687	0.2763
MEAN	0.7840	0.5543	0.6781	0.3668
S.DEV	0.0605	0.1297	0.0674	0.0751

1977 AD/AR TARSLL EFFECTIVENESS

```
          LOAD LIST EFFECTIVENESS     AD 18

  QTR     NET UNIT     GROSS UNIT     NET REGN     GROSS REGN

   1      0.7537       0.6102         0.6017       0.3447
   2      0.7820       0.5744         0.5903       0.3276
   3      0.7647       0.5182         0.5906       0.3399
   4      0.7908       0.5737         0.5998       0.3610
   5      0.8142       0.5631         0.6198       0.3768
   6      0.8196       0.5536         0.6157       0.3577
   7      0.8719       0.5175         0.6394       0.3423
   8      0.9081       0.6354         0.6443       0.3585
   9      0.8164       0.5706         0.6055       0.3714
  10      0.7464       0.5950         0.5645       0.3460
  11      0.7510       0.5709         0.5566       0.3264
  12      0.7953       0.5637         0.5987       0.3218
  13      0.9097       0.7521         0.7006       0.3751
  14      0.8063       0.6215         0.6482       0.3630
  15      0.8019       0.6249         0.6221       0.3214
  16      0.7884       0.5840         0.5991       0.3023
  17      0.8265       0.6265         0.6106       0.2853
  18      0.8269       0.6025         0.5954       0.2674
  19      0.8214       0.5814         0.6458       0.3059
  20      0.8283       0.5511         0.6466       0.3055
  21      0.7704       0.6037         0.5862       0.3051
  22      0.7124       0.6143         0.4643       0.2497

 MEAN     0.8049       0.5965         0.6066       0.3307

 S.DEV    0.0487       0.0506         0.0450       0.0333
```

1977 AD/AR TARSLL EFFECTIVENESS

```
          LOAD LIST EFFECTIVENESS     AD 19

 QTR      NET UNIT     GROSS UNIT     NET REQN      GROSS REQN

   1       0.7724        0.5655        0.6511         0.3446
   2       0.7870        0.5828        0.5989         0.3065
   3       0.8115        0.6224        0.5962         0.3092
   4       0.8212        0.6563        0.5815         0.3108
   5       0.8848        0.7807        0.5962         0.3557
   6       0.8294        0.7241        0.6217         0.3719
   7       0.7187        0.6264        0.5836         0.3538
   8       0.8045        0.5900        0.6030         0.3735
   9       0.8120        0.6905        0.5695         0.3398
  10       0.6517        0.6517        0.5624         0.3263
  11       0.7584        0.5444        0.5802         0.3204
  12       0.7042        0.5484        0.6005         0.3420
  13       0.6905        0.5175        0.5593         0.3121
  14       0.7510        0.5683        0.5339         0.2763
  15       0.7736        0.5385        0.5293         0.2709
  16       0.7087        0.5818        0.5290         0.2674
  17       0.7255        0.5736        0.5353         0.2710
  18       0.7633        0.6155        0.5572         0.2695
  19       0.8018        0.6429        0.5683         0.2690
  20       0.8218        0.6411        0.5797         0.2642
  21       0.6273        0.5170        0.5717         0.2682
  22       0.6725        0.5506        0.5226         0.2479

MEAN       0.7705        0.6133        0.5751         0.3077

S.DEV      0.0660        0.0675        0.0323         0.0392
```

1977 AD/AR TARSLL EFFECTIVENESS

LOAD LIST EFFECTIVENESS AD 26

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.8915	0.7210	0.7053	0.4770
2	0.8455	0.6392	0.6836	0.4346
3	0.8584	0.6272	0.6953	0.4155
4	0.8017	0.5924	0.6602	0.4322
5	0.8872	0.7148	0.6868	0.4804
6	0.8335	0.7280	0.6763	0.5212
7	0.8395	0.7527	0.7099	0.5349
8	0.8323	0.7617	0.7251	0.5173
9	0.7993	0.7128	0.7022	0.4444
10	0.8144	0.7303	0.6944	0.4531
11	0.7826	0.6031	0.6483	0.3799
12	0.7610	0.5365	0.6396	0.3654
13	0.7581	0.5206	0.6287	0.3337
14	0.7987	0.5563	0.6306	0.3506
15	0.8122	0.6105	0.6299	0.3462
16	0.7971	0.6052	0.6111	0.3263
17	0.7780	0.5653	0.6364	0.3159
18	0.7927	0.5969	0.6476	0.3253
19	0.8605	0.6994	0.6432	0.3516
20	0.8669	0.6963	0.6458	0.3849
21	0.8573	0.6805	0.6537	0.3922
22	0.8137	0.6430	0.6347	0.3799
MEAN	0.8219	0.6493	0.6633	0.4074
S.DEV	0.0383	0.0732	0.0322	0.0682

1977 AD/AR TARSLL EFFECTIVENESS

LOAD LIST EFFECTIVENESS AD 33

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.7009	0.5448	0.6360	0.3708
2	0.7398	0.6299	0.5936	0.3634
3	0.8984	0.7625	0.5894	0.3680
4	0.8202	0.6930	0.6499	0.4134
5	0.8969	0.7472	0.6146	0.4014
6	0.8898	0.6892	0.5227	0.3659
7	0.8673	0.7009	0.4872	0.3278
8	0.8272	0.6612	0.5440	0.3471
9	0.8760	0.7045	0.6753	0.4092
10	0.8025	0.6318	0.6572	0.3271
11	0.8293	0.6531	0.6553	0.3169
12	0.8531	0.6861	0.6278	0.2830
13	0.8503	0.6757	0.6393	0.3064
14	0.8003	0.6283	0.6145	0.2658
15	0.8298	0.6014	0.6128	0.2763
16	0.8509	0.6309	0.6236	0.2877
17	0.8419	0.6372	0.6327	0.3209
18	0.8534	0.6680	0.6281	0.2932
19	0.8604	0.6620	0.6396	0.3095
20	0.8611	0.6326	0.6553	0.2940
21	0.8407	0.5706	0.6127	0.3025
22	0.8467	0.5673	0.5885	0.2814
MEAN	0.8359	0.6556	0.6137	0.3290
S.DEV	0.0451	0.0543	0.0457	0.0446

1977 AD/AR TARSLL EFFECTIVENESS

LOAD LIST EFFECTIVENESS AR 5

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.7455	0.4396	0.6131	0.3341
2	0.7323	0.4643	0.6176	0.3499
3	0.8205	0.5993	0.6331	0.3955
4	0.8403	0.6389	0.6526	0.4193
5	0.7793	0.5836	0.5991	0.3672
6	0.7560	0.5492	0.5966	0.3573
7	0.7232	0.5351	0.5802	0.3447
8	0.7614	0.5740	0.6489	0.3684
9	0.6941	0.5352	0.6353	0.3503
10	0.6001	0.2525	0.5652	0.3063
11	0.5551	0.2154	0.5468	0.2853
12	0.5995	0.2160	0.5440	0.2990
13	0.7599	0.5273	0.5373	0.2695
14	0.6509	0.5135	0.4981	0.2439
15	0.6717	0.4870	0.5031	0.2212
16	0.6562	0.4587	0.5135	0.2219
17	0.5890	0.5553	0.4935	0.2138
18	0.5953	0.3991	0.4782	0.2213
19	0.6261	0.4759	0.4835	0.2527
20	0.6755	0.5493	0.5285	0.2538
21	0.7479	0.6251	0.5138	0.2612
22	0.7554	0.6034	0.5302	0.2677
MEAN	0.7005	0.4820	0.5596	0.2993
S.DEV	0.0811	0.1257	0.0569	0.0631

APPENDIX C

MLSF DATA ANALYSIS

```
MAX MONTHLY DEMAND          [illegible].
MAX PERIOD TOTAL            205402.
MAX DEMAND FREQ               [illegible]
MAX AVG REQT SIZE            15250.
NR RECORDS                  1[illegible]550
NR ITEMS                     27374

DEMAND FREQUENCY    1      NR ITEMS    [illegible]
DEMAND FREQUENCY    2      NR ITEMS    [illegible]
DEMAND FREQUENCY    3      NR ITEMS    [illegible]
DEMAND FREQUENCY    4      NR ITEMS    [illegible]
DEMAND FREQUENCY    5      NR ITEMS    [illegible]
DEMAND FREQUENCY    6      NR ITEMS    [illegible]
DEMAND FREQUENCY    7      NR ITEMS    [illegible]
DEMAND FREQUENCY    8      NR ITEMS    [illegible]
DEMAND FREQUENCY    9      NR ITEMS    [illegible]
DEMAND FREQUENCY   10      NR ITEMS    [illegible]
DEMAND FREQUENCY   11      NR ITEMS    [illegible]
DEMAND FREQUENCY   12      NR ITEMS    [illegible]
DEMAND FREQUENCY   13      NR ITEMS    [illegible]
DEMAND FREQUENCY   14      NR ITEMS    [illegible]
DEMAND FREQUENCY   15      NR ITEMS    [illegible]
DEMAND FREQUENCY   16      NR ITEMS    [illegible]
DEMAND FREQUENCY   17      NR ITEMS    [illegible]
DEMAND FREQUENCY   18      NR ITEMS    [illegible]
DEMAND FREQUENCY   19      NR ITEMS    [illegible]
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DEMAND FREQUENCY   23      NR ITEMS    [illegible]
DEMAND FREQUENCY   24      NR ITEMS    [illegible]
DEMAND FREQUENCY   25      NR ITEMS    [illegible]
DEMAND FREQUENCY   26      NR ITEMS    [illegible]
DEMAND FREQUENCY   27      NR ITEMS    [illegible]
DEMAND FREQUENCY   28      NR ITEMS    [illegible]
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DEMAND FREQUENCY   31      NR ITEMS    [illegible]
DEMAND FREQUENCY   32      NR ITEMS    [illegible]
DEMAND FREQUENCY   33      NR ITEMS    [illegible]
DEMAND FREQUENCY   34      NR ITEMS    [illegible]
DEMAND FREQUENCY   35      NR ITEMS    [illegible]
DEMAND FREQUENCY   36      NR ITEMS    [illegible]
DEMAND FREQUENCY   37      NR ITEMS    [illegible]
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DEMAND FREQUENCY   41      NR ITEMS    [illegible]
DEMAND FREQUENCY   42      NR ITEMS    [illegible]
DEMAND FREQUENCY   43      NR ITEMS    [illegible]
DEMAND FREQUENCY   44      NR ITEMS    [illegible]
DEMAND FREQUENCY   45      NR ITEMS    [illegible]
DEMAND FREQUENCY   46      NR ITEMS    [illegible]
DEMAND FREQUENCY   47      NR ITEMS    [illegible]
DEMAND FREQUENCY   48      NR ITEMS    [illegible]
DEMAND FREQUENCY   49      NR ITEMS    [illegible]
DEMAND FREQUENCY   50      NR ITEMS     137
```

MLSF DATA ANALYSIS

```
DISTRIBUTION OF AVG KEQN SIZE
    0     5    10    15    20    25    30    35    40    45    50    55    60    65    70    75    80    85    90    95   100
16517  4050  2376   572   900   413   269   176   180          94   422    78   104    50    61    85    73    42    34    25   100
  411    25    27    31    29    26    29    16    22          14    56     8    14    13    10    17    16    11     8     6   200
  134     9     7    13     5     5    11     5    10           7    41     5    13     9     2     6     5     4     2     1   300
   55     3     3     0     3     5     1     3     1           1     5     0     4     2     4     1     1     0     0     1   400
   14     2     1     4     2     1     0     1     1           1     7     1     1     0     0     2     1     2     0   137   500
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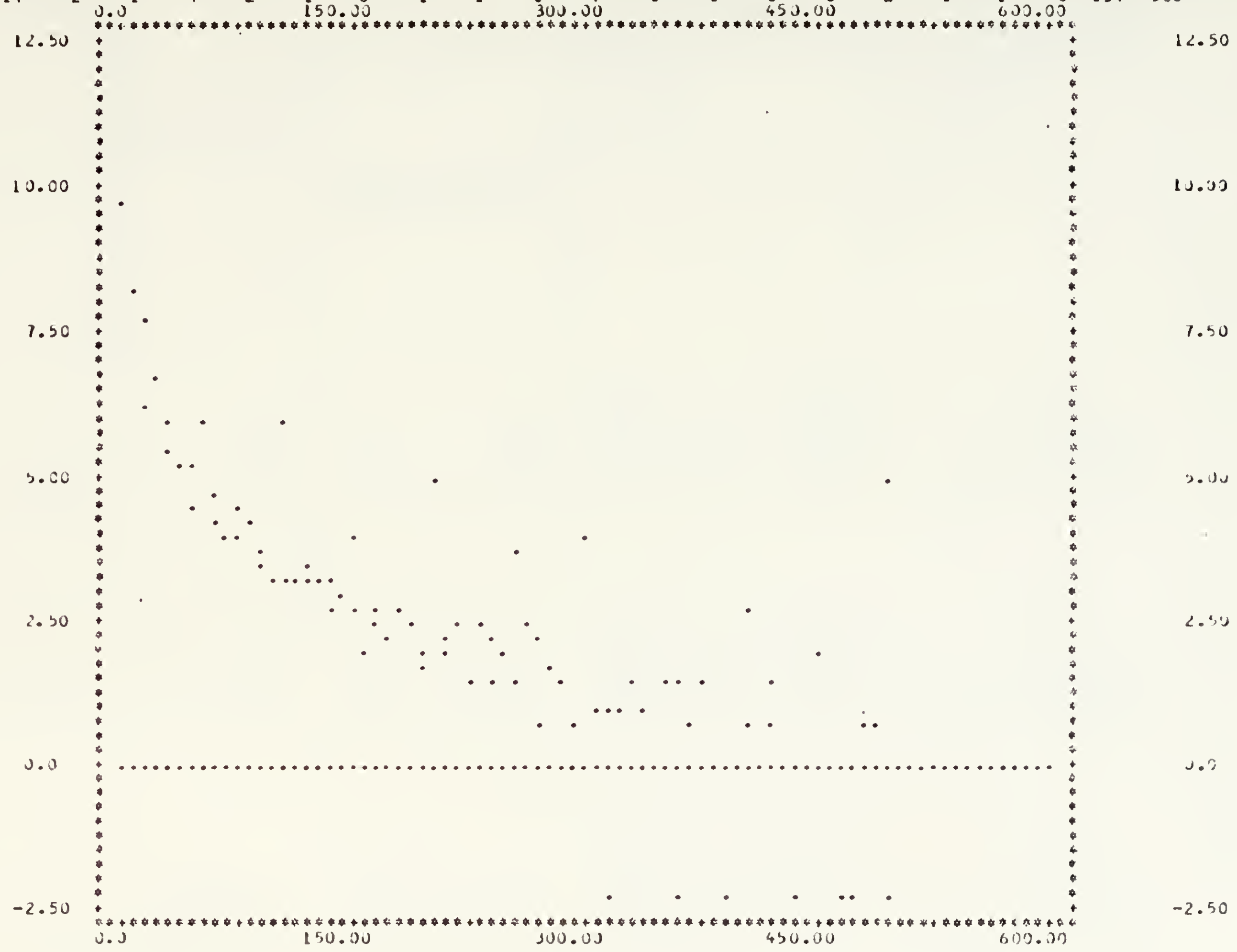
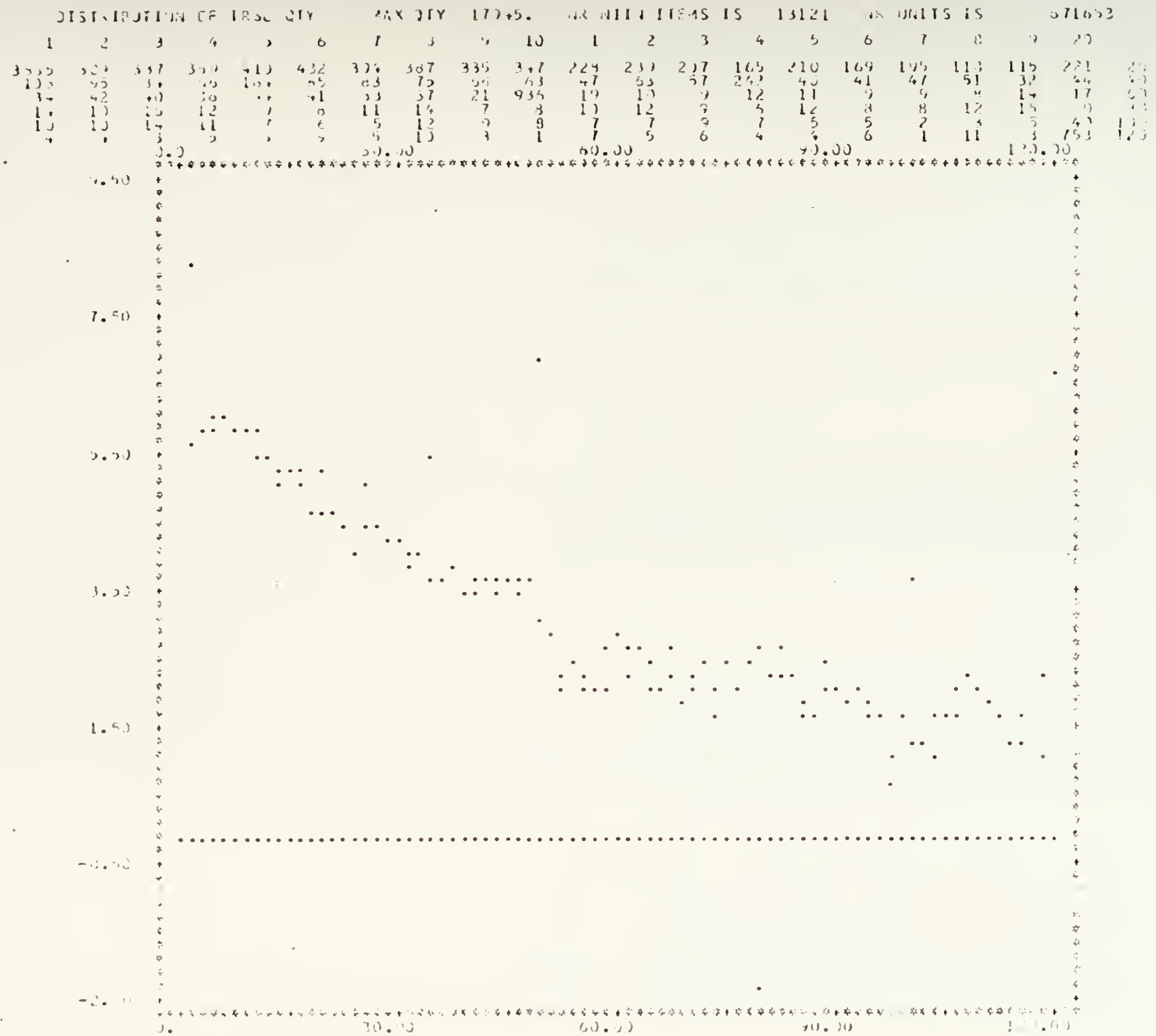


APPENDIX D

STATISTICS FOR MODEL WITH E=AQD

```
                     TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                              NER           ER          TOTAL
CANDIDATES                   14567       139691       154258
LL RANGE                      3557         9660        13217
LL VALUE                   384927.      435236.      820163.
ADDS TO LL                    3557         9660        13217
ADDS VALUE                 384927.      435236.      820163.
DELETES FM LL                    0            0            0
DELETES VALUE                   0.           0.           0.
FORCED ON LL                  1540         2127         3667
CONSTRAINED QTY                  0         1145         1145

        EFFECTIVENESS DATA
UNITS SAT                  130451.       64530.      194980.
REQN SAT                     2050.       15447.       17497.
DMD   LL                   154380.       73384.      232755.
      NLL                   23807.       17011.       45313.
      ALL                                            273531.
FREQ  LL                     3546.       20830.       24376.
      NLL                    1742.        1963.        3706.
      ALL                                             28082.
NET UNIT EFF                0.8450       0.8233       0.8377
GROSS UNIT EFF              0.7121       0.5764       0.5994
NET REQN EFF                0.5732       0.7416       0.7178
GROSS REQN EFF              0.3877       0.6777       0.6231

        AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL             3557         4150         7707
               NLL            9926         9040        18966
               ALL                                     26673
BRF X POP      LL                0         5510         5510
               NLL               0       107747       107747
               ALL                                    113257
FORCED FCST    LL                0            0            0
               NLL            1084        13244        14328
               ALL                                     14328

        NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                1345         1863         3208
            NLL                  0            0            0
            ALL                                         3208
MIN RISK    LL                 166         2899         3065
            NLL                  0            0            0
            ALL                                         3065

        OVERRIDES APPLIED
MANDATORY                        0            0            0
MAX QTY                          0            0            0
MIN QTY                          0            0            0
DELETE                           0            0            0
```

STATISTICS FOR MODEL WITH E=AQD



STATISTICS FOR MODEL WITH E=AQD

LOAD LIST EFFECTIVENESS ATLANTIC FLEET

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.8012	0.5965	0.6653	0.3774
2	0.8076	0.6062	0.6390	0.3618
3	0.8200	0.6220	0.6420	0.3769
4	0.8070	0.6283	0.6435	0.3965
5	0.8299	0.6579	0.6567	0.4050
6	0.8010	0.6287	0.6129	0.3939
7	0.7953	0.6207	0.6197	0.3397
8	0.8060	0.6571	0.6521	0.4090
9	0.7457	0.6521	0.6633	0.3973
10	0.7674	0.5776	0.6400	0.3563
11	0.7542	0.5382	0.6257	0.3442
12	0.7559	0.5403	0.6256	0.3411
13	0.7985	0.6102	0.6337	0.3350
14	0.7705	0.5685	0.6074	0.3132
15	0.7772	0.5213	0.5922	0.2904
16	0.7661	0.5264	0.5891	0.2849
17	0.7603	0.5146	0.5911	0.2303
18	0.7766	0.5782	0.5961	0.2824
19	0.8049	0.6030	0.6036	0.2928
20	0.8007	0.6065	0.6177	0.3022
21	0.7511	0.5864	0.5935	0.3033
22	0.7510	0.5865	0.5594	0.2874
MEAN	0.7869	0.5921	0.6205	0.3425
S.DEV	0.0233	0.0433	0.0271	0.0465

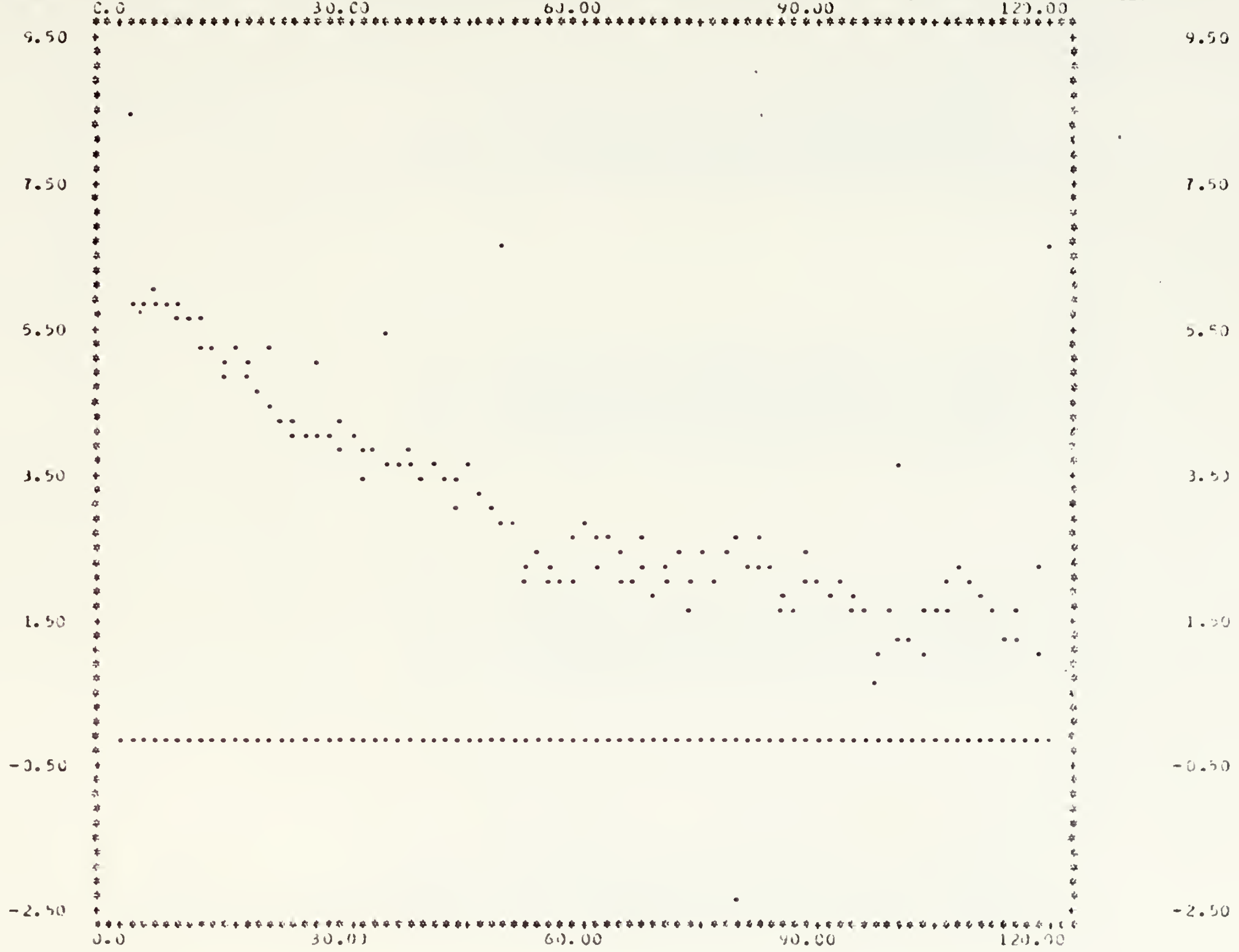
APPENDIX E

STATISTICS FOR MODEL WITH K3=0.6

```
                         TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                                      NER           ER            TOTAL
CANDIDATES                          14567       139691           154258
LL RANGE                             3557         9883            13440
LL VALUE                          384927.      391644.          776572.
ADDS TO LL                           3557         9883            13440
ADDS VALUE                        384927.      391644.          776572.
DELETES FM LL                           0            0                0
DELETES VALUE                          0.           0.               0.
FORCED ON LL                         1540         3275             4815
CONSTRAINED QTY                         0          683              683

         EFFECTIVENESS DATA
UNITS SAT                         130451.       63541.          193992.
REQN SAT                            2050.       14459.           16509.
DMD   LL                          154380.       95424.          249803.
      NLL                          28807.       17253.           46060.
      ALL                                                       295863.
FREQ  LL                            3546.       37899.           41444.
      NLL                           1742.        1963.            3706.
      ALL                                                        45150.
NET UNIT EFF                       0.8450       0.6659           0.7766
GROSS UNIT EFF                     0.7121       0.5639           0.6557
NET REQN EFF                       0.5782       0.3815           0.3983
GROSS REQN EFF                     0.3877       0.3627           0.3656

         AVERAGE DEMAND COMPUTATION
HISTORICAL DMC LL                    3557         4150             7707
               NLL                   9926         9040            18966
               ALL                                                26673
BRF X POP      LL                       0         5733             5733
               NLL                      0       107601           107601
               ALL                                               113334
FORCED FCST    LL                       0            0                0
               NLL                   1084        13167            14251
               ALL                                                14251

         NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                       1345         2844             4189
            NLL                         0            0                0
            ALL                                                    4189
MIN RISK    LL                        166         1273             1444
            NLL                         0            0                0
            ALL                                                    1444

         OVERRIDES APPLIED
MANDATORY                               0            0                0
MAX QTY                                 0            0                0
MIN QTY                                 0            0                0
DELETE                                  0            0                0
```

STATISTICS FOR MODEL WITH K3=0.6

```
    DISTRIBUTICN CF TRSL CTY       MAX QTY  17945.     NR NIIN ITEMS IS        13334
   1     2     3     4     5     6     7     8     9    10     1     2     3     4     5     6     7     8     9    20

4921   371   359   370   420   372   363   328   279   288   205   201   163   140   183   130   155   102    98   200    20
  75    78    64    59   153    60    58    77    51    56    33    53    45   249    41    40    37    46    33    41    40
  38    32    33    22    37    29    27    24    20   820    19    10     9    12    11     9     9     8    14    17    60
  14    10    16    12     7     8    11    14     7     3    10    12     9     6    12     8     6    12    15     0    80
  10    10    14    11     7     6     5    12     9     8     7     7     9     7     5     5     2     3     5    40   100
   4     4     3     5     6     9     5    10     8     1     7     5     6     4     4     6     1    11     3   753   120
```



STATISTICS FOR MODEL WITH K3=0.6

```
          LOAD LIST EFFECTIVENESS      ATLANTIC FLEET
  QTR     NET UNIT     GROSS UNIT      NET REQN      GROSS REQN

    1      0.8010        0.5965         0.6637         0.3766
    2      0.8072        0.6057         0.6361         0.3605
    3      0.8196        0.6213         0.6390         0.3758
    4      0.8066        0.6280         0.6401         0.3953
    5      0.8297        0.6577         0.6370         0.4043
    6      0.8009        0.6287         0.6120         0.3936
    7      0.7959        0.6205         0.6179         0.3859
    8      0.8077        0.5569         0.6505         0.4082
    9      0.7952        0.6517         0.6603         0.3959
   10      0.7689        0.5773         0.6362         0.3649
   11      0.7536        0.5379         0.6214         0.3421
   12      0.7554        0.5400         0.6213         0.3393
   13      0.7973        0.6099         0.6298         0.3342
   14      0.7695        0.5580         0.6051         0.3112
   15      0.7760        0.5209         0.5870         0.2330
   16      0.7553        0.5258         0.5831         0.2821
   17      0.7594        0.5142         0.5849         0.2776
   18      0.7757        0.5777         0.5894         0.2794
   19      0.8042        0.6025         0.5965         0.2895
   20      0.7996        0.6058         0.6086         0.2978
   21      0.7601        0.5857         0.5855         0.2993
   22      0.7493        0.5857         0.5519         0.2842

 MEAN      0.7863        0.5913         0.6161         0.3404

 S.DEV     0.0234        0.0434         0.0287         0.0475
```

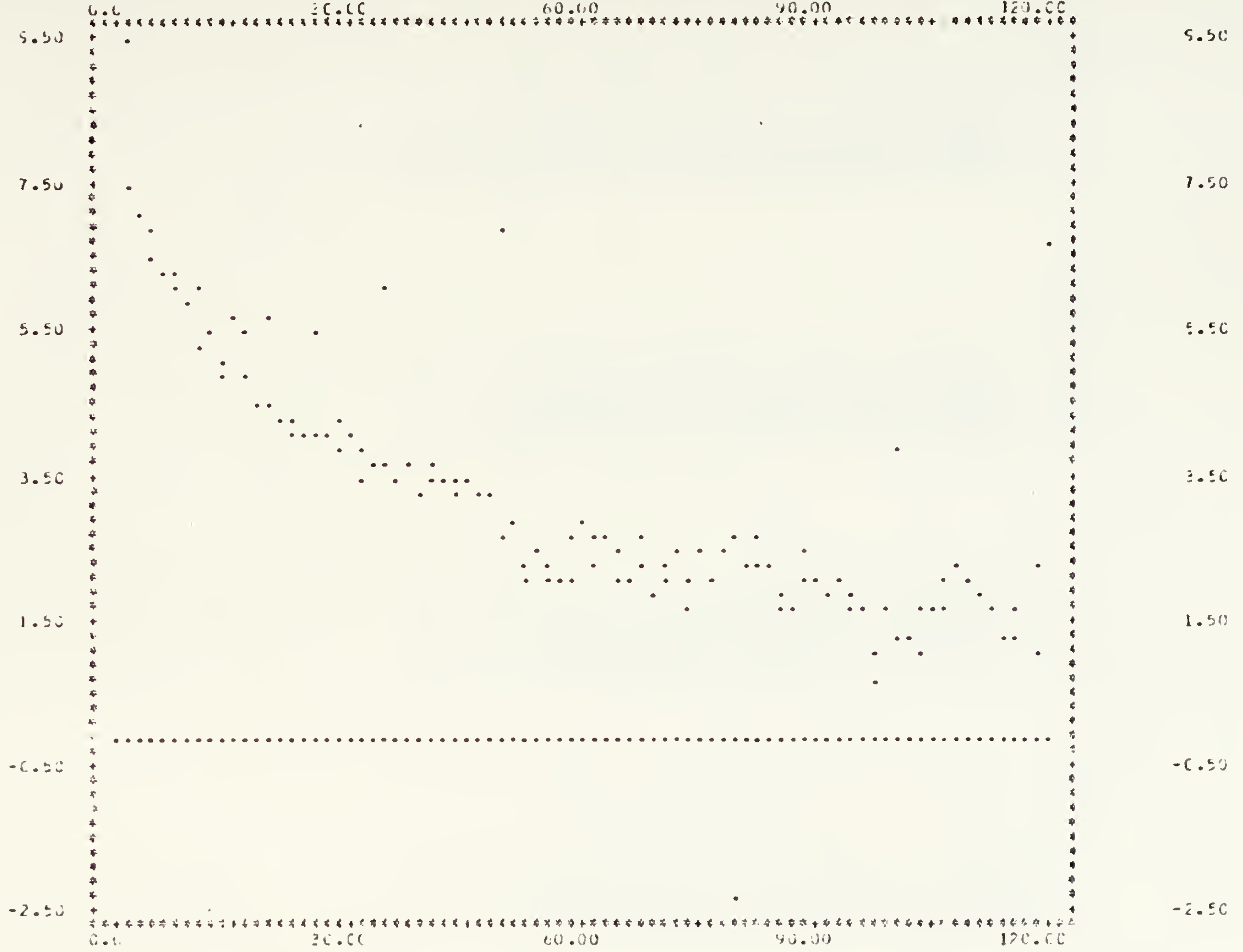
APPENDIX F

STATISTICS FOR MODEL WITH RC=4

```
                          TRSLL LOAD LIST OUTPUT STATISTICS

   LE =   0.154   LN =   0.154   T =   1.0   K13 = 1.

                                         NEF             EF            TOTAL
CANDIDATES                             14567         139691           154258
LL RANGE                                4694          20532            25226
LL VALUE                             485678.       1067147.         1552825.
ADDS TO LL                              4694          20532            25226
ADDS VALUE                           485678.       1067147.         1552825.
DELETES FM LL                              0              0                0
DELETES VALUE                             0.             0.               0.
FORCED ON LL                            2501           8883            11384
CONSTRAINED QTY                            0            704              704

          EFFECTIVENESS DATA
UNITS SAT                            130779.         68182.          198961.
REQN SAT                               2224.         18260.           20484.
DMD    LL                            155447.        100790.          256237.
       NLL                            27739.          7900.           35639.
       ALL                                                           291876.
FREQ   LL                              4012.         41436.           45448.
       NLL                             1277.           848.            2125.
       ALL                                                            47573.
NET UNIT EFF                          0.8413         0.6765           0.7765
GROSS UNIT EFF                        0.7139         0.6273           0.6817
NET REQN EFF                          0.5544         0.4407           0.4507
GROSS REQN EFF                        0.4206         0.4318           0.4306

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                       4694           7813            12507
               NLL                      8789           5377            14166
               ALL                                                     26673
BRF X POP      LL                          0          12719            12719
               NLL                         0         100538           100538
               ALL                                                    113257
FORCED FCST    LL                          0              0                0
               NLL                      1084          13244            14328
               ALL                                                     14328

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                          2248           7779            10027
            NLL                            0              0                0
            ALL                                                        10027
MIN RISK    LL                           171           1893             2064
            NLL                            0              0                0
            ALL                                                         2064

          OVERRIDES APPLIED
MANDATORY                                  0              0                0
MAX QTY                                    0              0                0
MIN QTY                                    0              0                0
DELETE                                     0              0                0
```

STATISTICS FOR MODEL WITH RC=4

```
DISTRIBUTION OF TRSL QTY      MAX QTY   17945.      NR NIIN ITEMS IS        24938
    1     2     3     4     5     6     7     8     9    10     1     2     3     4     5     6     7     8     9    20

12215  1655  1149   551   704   551   507   459   387   475   201   270   165   140   307   123   260    58    59   326    20
   73    74    65    60   251    59    56    77    45    57    33    53    44   416    39    36    37    44    29    43    40
   40    34    35    25    35    25    26    28    16   566    19    10     9    12    11     9     9     8    14    17    60
   14    10    16    12     9     8    11    14     7     8    10    12     9     6    12     8     8    12    15     0    80
   10    10    14    11     7     6     5    12     9     6     7     7     9     7     5     5     2     2     5    45   100
    4     4     3     5     6     9     5    10     8     1     7     5     6     4     4     6     1    11     3   753   120
```



STATISTICS FOR MODEL WITH RC=4

LOAD LIST EFFECTIVENESS ATLANTIC FLEET

QTR	NET UNIT	GROSS UNIT	NET REQN	GROSS REQN
1	0.7899	0.6045	0.6404	0.4430
2	0.7935	0.6131	0.6071	0.4136
3	0.8065	0.6279	0.6096	0.4233
4	0.7925	0.6332	0.6077	0.4309
5	0.8197	0.6622	0.6100	0.4434
6	0.7895	0.6330	0.5866	0.4299
7	0.7841	0.6247	0.5946	0.4278
8	0.7977	0.6615	0.6330	0.4477
9	0.7363	0.6565	0.6380	0.4364
10	0.7570	0.5831	0.6085	0.4064
11	0.7409	0.5442	0.5909	0.3861
12	0.7401	0.5455	0.5914	0.3834
13	0.7822	0.6167	0.5955	0.3772
14	0.7537	0.5736	0.5650	0.3457
15	0.7562	0.5258	0.5445	0.3209
16	0.7489	0.5298	0.5385	0.3148
17	0.7425	0.5184	0.5405	0.3128
18	0.7611	0.5820	0.5467	0.3148
19	0.7884	0.6057	0.5563	0.3240
20	0.7844	0.6097	0.5636	0.3314
21	0.7486	0.5893	0.5448	0.3335
22	0.7373	0.5898	0.5084	0.3155
MEAN	0.7728	0.5969	0.5828	0.3801
S.DEV	0.0245	0.0434	0.0362	0.0518

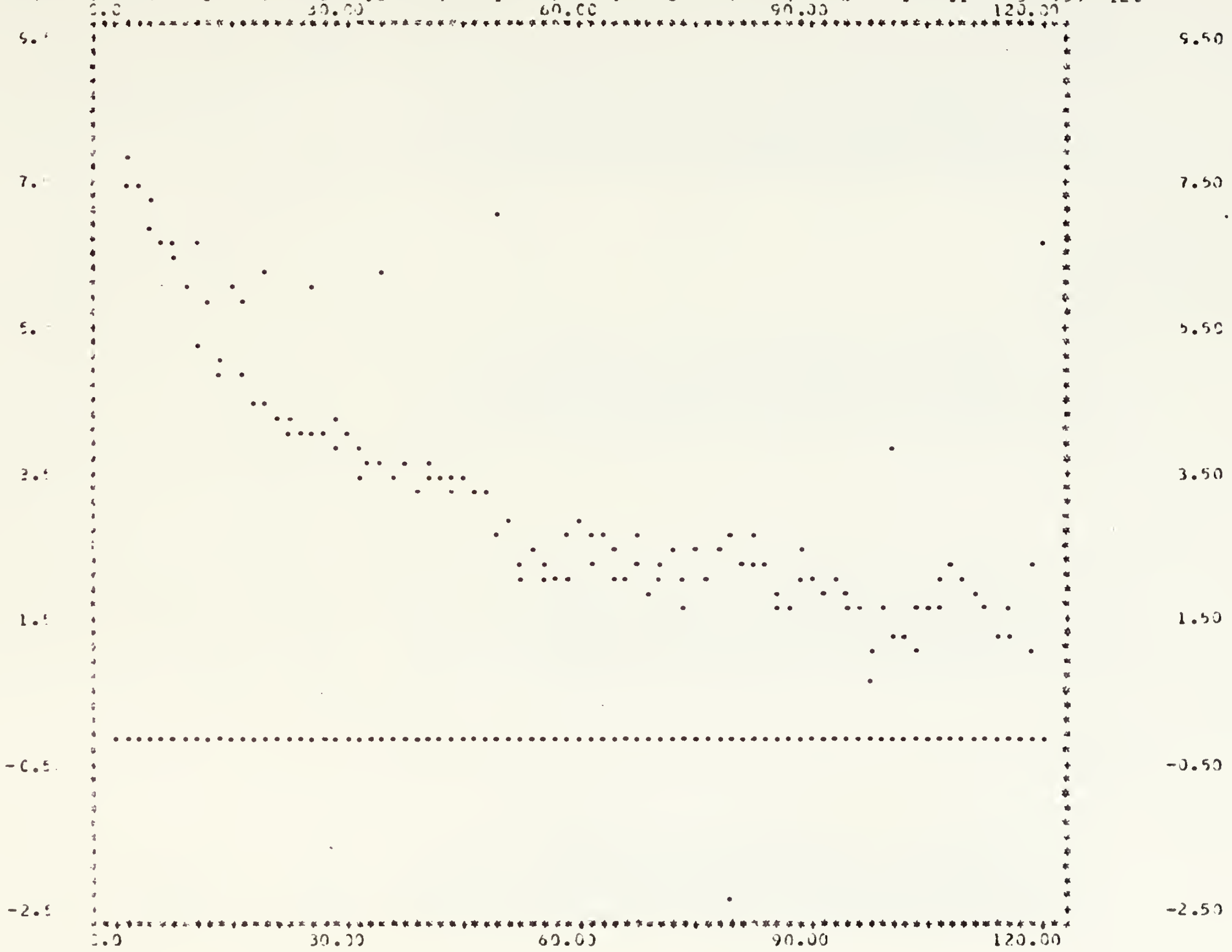
APPENDIX G

STATISTICS FOR NO-RANGE-CUT MODEL

```
                       TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154   T =  1.0  K13 = 1.
                                     NER           ER         TOTAL
CANDIDATES                         14567       139691        154258
LL RANGE                            2156        17759         19915
LL VALUE                         216394.      158641.       375035.
ADDS TO LL                          2156        17759         19915
ADDS VALUE                       216394.      158641.       375035.
DELETES FM LL                          0            0             0
DELETES VALUE                         0.           0.            0.
FORCED ON LL                           0            0             0
CONSTRAINED QTY                        0          810           810

          EFFECTIVENESS DATA
UNITS SAT                        130418.       67755.       198173.
REQN SAT                           2026.       18193.        20219.
DMD   LL                         141682.       76423.       218105.
      NLL                         41504.       32242.        73746.
      ALL                                                   291850.
FREQ  LL                           2483.       22575.        25058.
      NLL                          2805.        2981.         5786.
      ALL                                                    30844.
NET UNIT EFF                      0.9205       0.8866        0.9086
GROSS UNIT EFF                    0.7119       0.6235        0.6790
NET REQN EFF                      0.8160       0.8059        0.8069
GROSS REQN EFF                    0.3832       0.7119        0.6555

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                   2156         4277          6433
               NLL                 11327         8913         20240
               ALL                                            26673
BRF X POP      LL                      0        13482         13482
               NLL                     0        99775         99775
               ALL                                           113257
FORCED FCST    LL                      0            0             0
               NLL                  1084        13244         14328
               ALL                                            14328

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                         0            6             6
            NLL                     2248        68262         70510
            ALL                                               70516
MIN RISK    LL                       171         2998          3169
            NLL                        0         1576          1576
            ALL                                                4745

          OVERRIDES APPLIED
MANDATORY                              0            0             0
MAX QTY                                0            0             0
MIN QTY                                0            0             0
DELETE                                 0            0             0
```

STATISTICS FOR NO-RANGE-CUT MODEL

```
 DISTR.   TION OF TRSL QTY      MAX QTY  17945.     JR NIIN ITEMS IS       19648

   1    2     3    4    5    6    7    8    9   10    1    2    3    4    5    6    7    8    9   20

1795 270c    4 1624 1074  806  751  663  490  610  201  381  172  140  432  123  398   98   59  525    20
  73   74    5   60  410   55   56   77   49   57   33   53   44  598   39   36   37   44   28   43    40
  33   34    5   25   35   25   26   28   16 1244   13   10    9   12   11    9    9    8   14   17    60
  14   10    5   12    9    8   11   14    7    6   10   12    9    6   12    8    8   12   15    0    80
  10   10    4   11    7    6    5   12    9    8    7    7    9    7    5    5    4    3    5   45   100
   4    4    3    5    6    9    5   10    3    1    7    5    6    4    4    6    1   11    3  753   120
```



STATISTICS FOR NO-RANGE-CUT MODEL

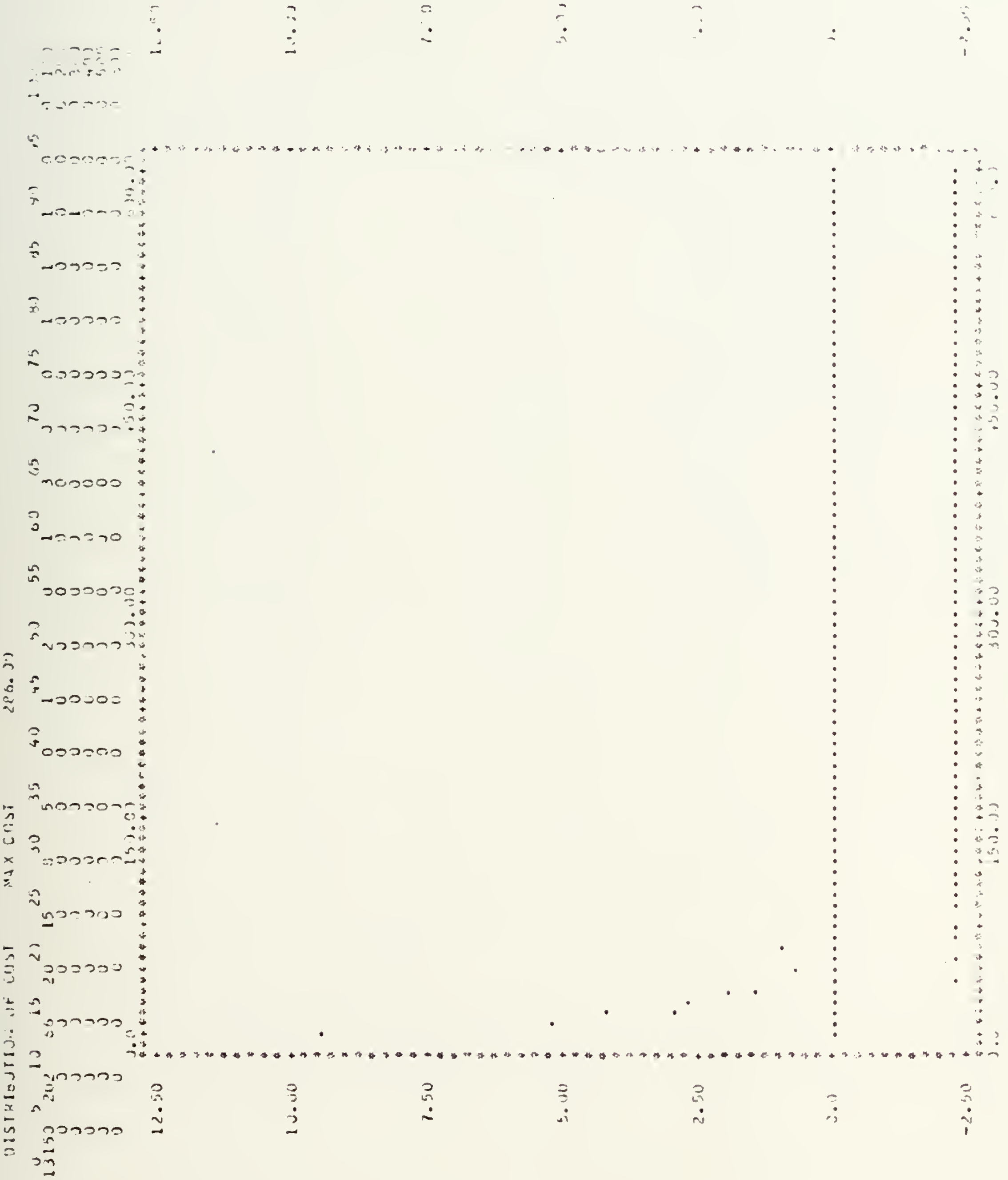
```
              LOAD LIST EFFECTIVENESS     ATLANTIC FLEET
   QTR        NET UNIT     GROSS UNIT      NET REGN     GROSS REGN

     1         0.8451        0.5969         0.8295        0.3640
     2         0.8484        0.6080         0.7941        0.3457
     3         0.8576        0.6235         0.8023        0.3592
     4         0.8360        0.6293         0.7934        0.3773
     5         0.8597        0.6578         0.7983        0.3861
     6         0.8328        0.6287         0.7790        0.3677
     7         0.8247        0.6204         0.7723        0.3618
     8         0.8350        0.6576         0.8019        0.3783
     9         0.8269        0.6515         0.8145        0.3658
    10         0.8062        0.5776         0.7987        0.3405
    11         0.7842        0.5399         0.7737        0.3224
    12         0.7776        0.5418         0.7733        0.3215
    13         0.8192        0.6127         0.7738        0.3196
    14         0.7871        0.5703         0.7410        0.2978
    15         0.7977        0.5227         0.7216        0.2777
    16         0.7855        0.5269         0.7171        0.2729
    17         0.7785        0.5156         0.7117        0.2689
    18         0.7944        0.5789         0.7146        0.2706
    19         0.8240        0.6033         0.7227        0.2795
    20         0.8220        0.6063         0.7284        0.2867
    21         0.7831        0.5864         0.7066        0.2893
    22         0.7752        0.5865         0.6817        0.2747

 MEAN          0.8137        0.5928         0.7614        0.3240

 S.DEV         0.0277        0.0430         0.0420        0.0418
```

APPENDIX H

STATISTICS FOR MODIFIED NO-RANGE-CUT MODEL

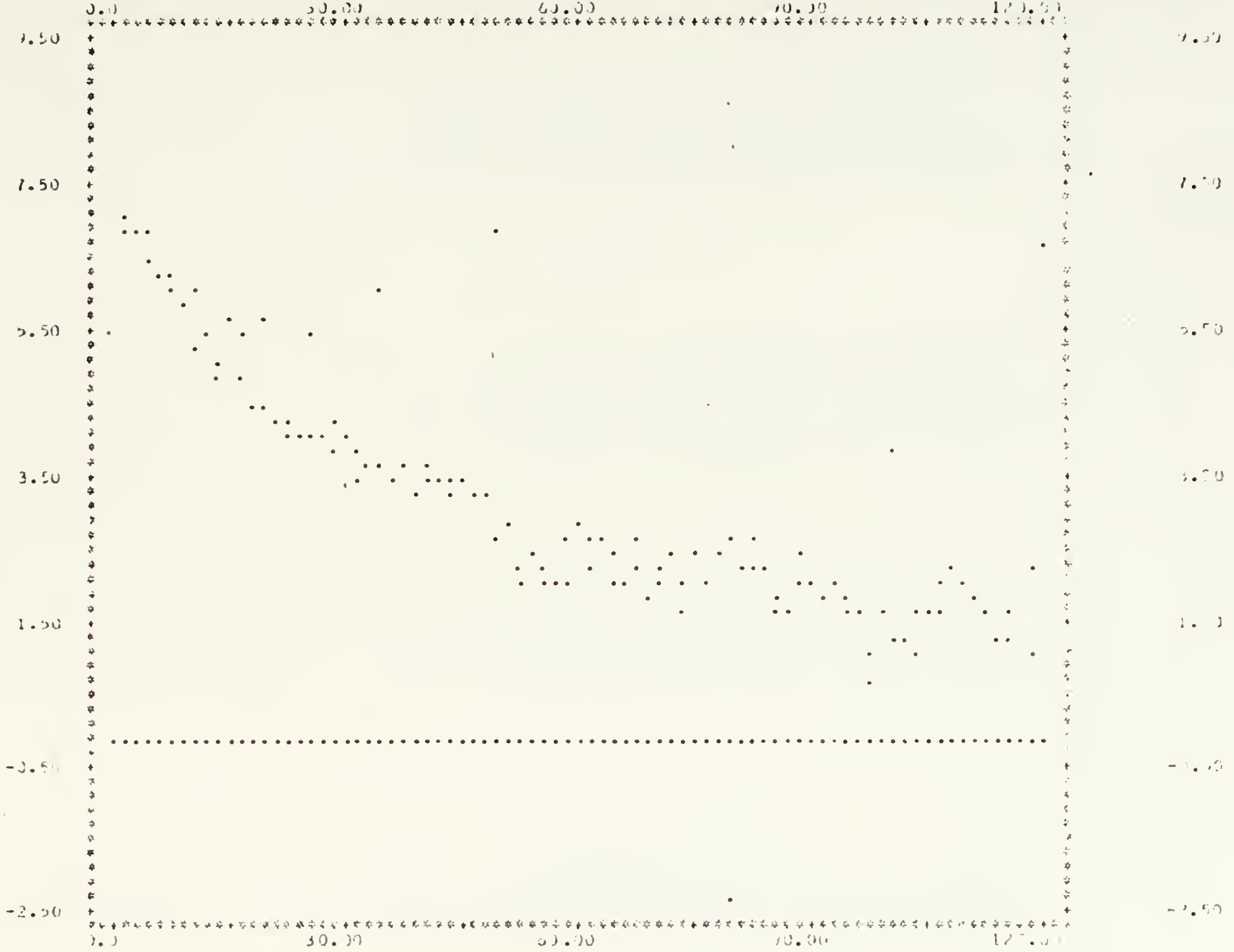
```
                     TROLL LOAD LIST OUTPUT STATISTICS

      LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                                    NER          ER          TOTAL
CANDIDATES                        14557      139691         154258
LL RANGE                           2156       11321          13477
LL VALUE                        216394.     150361.        366755.
ADDS TO LL                         2156       11321          13477
ADDS VALUE                      216394.     150361.        366755.
DELETES FM LL                         0           0              0
DELETES VALUE                        0.          0.             0.
FORCED ON LL                          0           0              0
CONSTRAINED QTY                       0         704            704

          EFFECTIVENESS DATA
UNITS SAT                       130418.      66141.        196559.
REQN SAT                          2026.      16598.         18624.
DMD    LL                       141682.      74747.        216429.
       NLL                       41504.      33974.         75478.
       ALL                                                 291907.
FREQ   LL                         2483.      20907.         23390.
       NLL                        2805.       3050.          5855.
       ALL                                                  29245.
NET UNIT EFF                     0.9205      0.8649         0.9082
GROSS UNIT EFF                   0.7119      0.6084         0.6734
NET REQN EFF                     0.8150      0.7939         0.7962
GROSS REQN EFF                   0.3332      0.6928         0.6366

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                  2156        3367           5523
               NLL                11327        9323          20650
               ALL                                           26173
BRF X POP      LL                     0        7454           7454
               NLL                    0      105803         105803
               ALL                                          113257
FORCED FCST    LL                     0           0              0
               NLL                 1084       13244          14328
               ALL                                           14328

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                        0           6              6
            NLL                    2248        7773          10021
            ALL                                              10027
MIN RISK    LL                      171        1893           2064
            NLL                       0           0              0
            ALL                                               2064

          OVERRIDES APPLIED
MANDATORY                             0           0              0
MAX QTY                               0           0              0
MIN QTY                               0           0              0
DELETE                                0           0              0
```

STATISTICS FOR MODIFIED NO-RANGE-CUT MODEL



STATISTICS FOR MODIFIED NO-RANGE-CUT MODEL

```
DISTRIBUTION OF TRSL QTY     MAX QTY  17945.     NR WITH ITEMS IS      13326
  1    2    3    4    5    6    7    8    9   10    1    2    3    4    5    6    7    8    9   20
931 1320 1036  728  633  542  498  453  382  462  231  267  155  140  307  123  260   98   97  376   20
 73   74   55   60  251   59   56   77   49   57   33   54   44  415   39   35   37   44   28   43   40
 30   31   36   25   35   29   26   23   16  966   19   10    9   12   11    9    5    4   16   17   60
 14   10   16   12    7    8   11   14    7    3   10   12    7    6   12    8    8   12   15    1   80
 10   10   14   11    7    5    5   12    9    3    7    7    9    7    5    5    2    3    5   45  100
  4    4    3    5    5    9    5   10    8    1    7    5    6    4    4    6    1   11    3  755  120
```



STATISTICS FOR MODIFIED NO-RANGE-CUT MODEL

```
           LOAD LIST EFFECTIVENESS      ATLANTIC FLEET
 QTR        NET UNIT     GROSS UNIT      NET REQN      GROSS REQN

   1        0.8468         0.5952         0.8326         0.3567
   2        0.8512         0.6057         0.7989         0.3369
   3        0.8621         0.6209         0.8031         0.3508
   4        0.8421         0.5270         0.8002         0.3704
   5        0.8564         0.5560         0.8032         0.3798
   6        0.8597         0.6272         0.7838         0.3623
   7        0.8510         0.6183         0.7764         0.3563
   8        0.8340         0.6559         0.8059         0.3727
   9        0.8261         0.6497         0.8160         0.3569
  10        0.8062         0.5755         0.8024         0.3311
  11        0.7869         0.5375         0.7789         0.3127
  12        0.7815         0.5393         0.7816         0.3138
  13        0.8223         0.6104         0.7800         0.3127
  14        0.7908         0.5684         0.7468         0.2914
  15        0.8016         0.5210         0.7268         0.2715
  16        0.7901         0.5255         0.7207         0.2568
  17        0.7840         0.5142         0.7176         0.2633
  18        0.7994         0.5774         0.7186         0.2542
  19        0.8273         0.6019         0.7281         0.2732
  20        0.8249         0.6048         0.7327         0.2796
  21        0.7357         0.5850         0.7116         0.2329
  22        0.7776         0.5653         0.6848         0.2633

MEAN        0.8176         0.5911         0.7662         0.3170

S.DEV       0.0280         0.0425         0.0420         0.0416
```

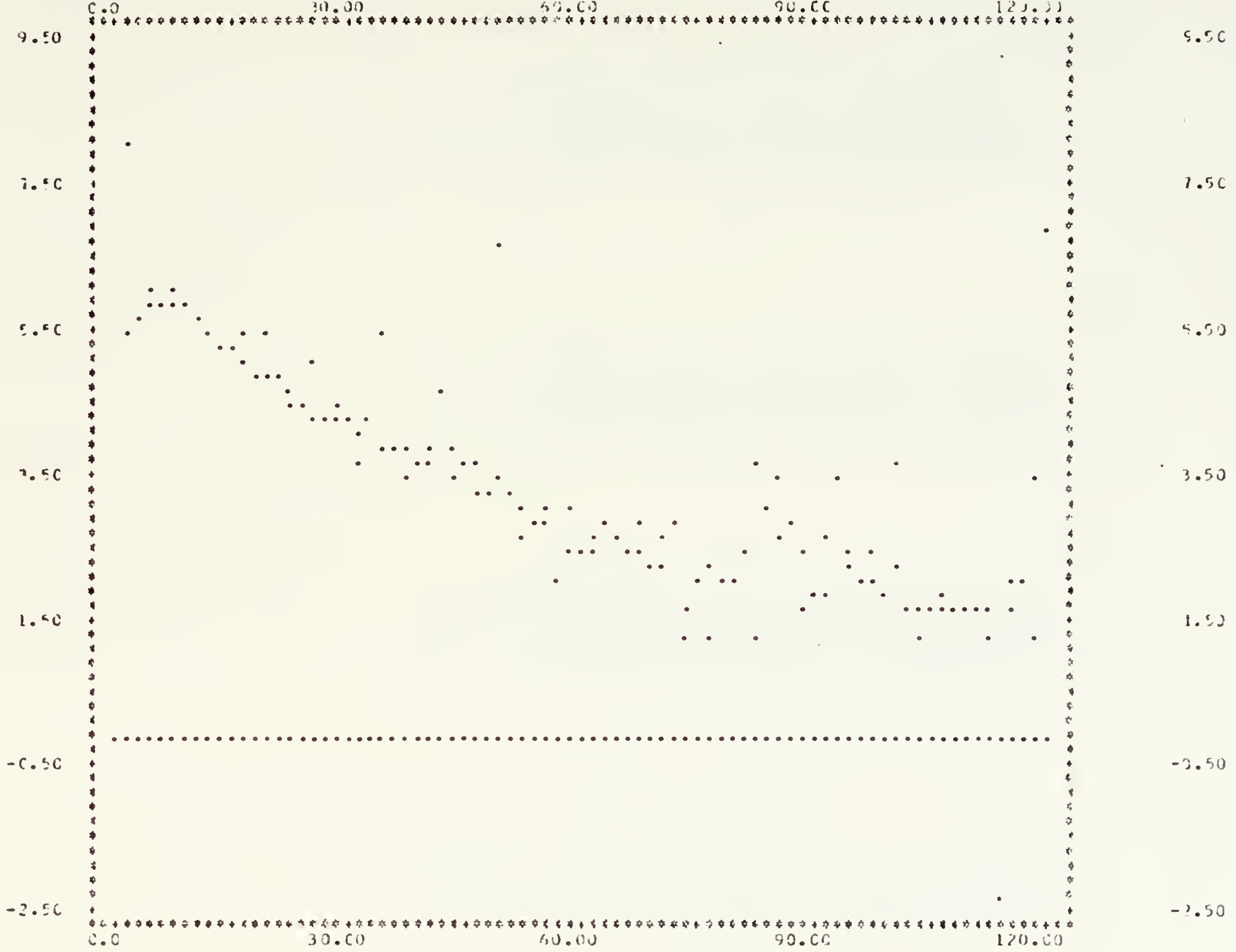
APPENDIX I

STATISTICS FOR MODEL WITH A=1

```
                  TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                                NER          ER        TOTAL
CANDIDATES                     14567      139691      154258
LL RANGE                        3557        9660       13217
LL VALUE                     885562.     515954.    1401516.
ADDS TO LL                      3557        9660       13217
ADDS VALUE                   885562.     515954.    1401516.
DELETES FM LL                      0           0           0
DELETES VALUE                     0.          0.          0.
FORCED ON LL                     520        2500        3020
CONSTRAINED QTY                    0         630         680

         EFFECTIVENESS DATA
UNITS SAT                    149392.      69132.     218524.
REQN SAT                       2874.      14735.      17610.
DMD   LL                     154380.      91118.     245498.
      NLL                     28807.      17011.      45818.
      ALL                                            291316.
EFFEC LL                       3546.      34222.      37767.
      NLL                      1742.       1963.       3706.
      ALL                                             41473.
NET UNIT EFF                  0.9677      0.7587      0.8901
GROSS UNIT EFF                0.8155      0.6393      0.7501
NET REQN EFF                  0.8106      0.4306      0.4663
GROSS REQN EFF                0.5436      0.4072      0.4246

         AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL               3557        4150        7707
               NLL              9926        9040       18966
               ALL                                     26673
BFF X PCP      LL                  0        5510        5510
               NLL                 0      107747      107747
               ALL                                    113257
FORCED FCST    LL                  0           0           0
               NLL              1084       13244       14328
               ALL                                     14328

         NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                   427        2179        2606
            NLL                    0           0           0
            ALL                                         2606
MIN RISK    LL                  1438        2601        4039
            NLL                    0           0           0
            ALL                                         4039

         OVERRIDES APPLIED
MANDATORY                          0           0           0
MAX QTY                            0           0           0
MIN QTY                            0           0           0
DELETE                             0           0           0
```

STATISTICS FOR MODEL WITH A=1

```
DISTRIBUTION OF TRSL QTY      MAX QTY   17945.      NR NIIN ITEMS IS        12121
   1     2     3     4     5     6     7     8     9    10     1     2     3     4     5     6     7     8     9    20

3161   264   305   385   419   348   405   363   382   319   273   235   200   192   218   157   243   134   144   244    20
 144   100    92    97   171    81    68    84    72    69    43    56    75   254    53    46    47    35    42    46    40
  39   112    45    35    35    27    43    29    30   843    27    15    23    17    24    20     9    12    23    17    60
  16    13    17    14    16    12    19    12    10    11    14    19     4     6     9    10     4     9     8     9    80
  12     4    40    21    31    15    19    12     6     7     7    14    30    12    10     9    13     8     7    40   100
  10     6     4     6     5     5     7     5     5     5     5     5     4     0     6     4     3    34     4  1048   120
```



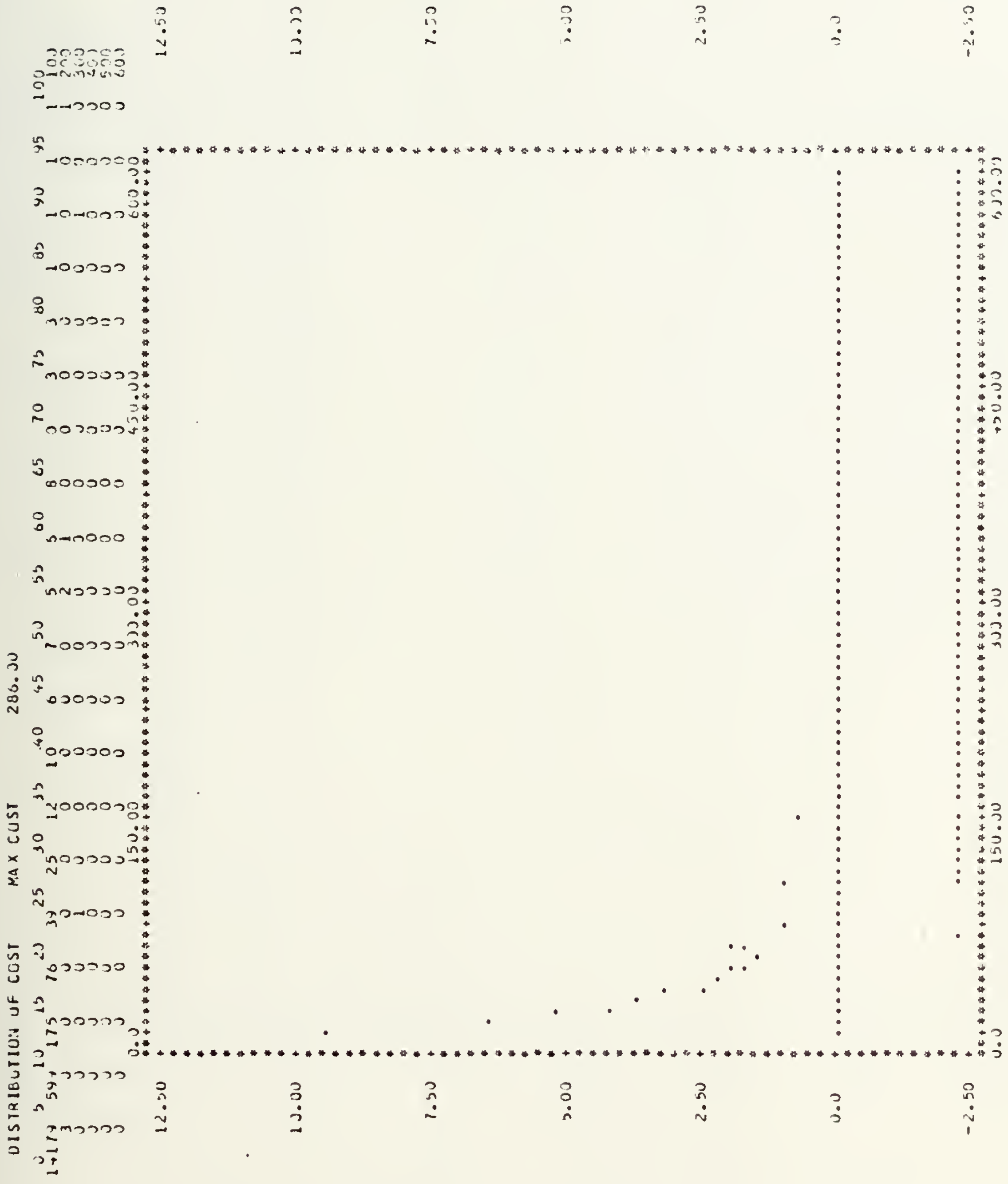
```
STATISTICS FOR MODEL WITH A=1




           LOAD LIST EFFECTIVENESS    ATLANTIC FLEET

   QTR     NET UNIT     GROSS UNIT     NET REGN     GROSS REGN

     1      0.8614        0.6407        0.7929        0.4510
     2      0.8751        0.6553        0.7786        0.4412
     3      0.8824        0.6684        0.7716        0.4531
     4      0.8642        0.6723        0.7702        0.4743
     5      0.8843        0.7003        0.7604        0.4819
     6      0.8605        0.6743        0.7448        0.4783
     7      0.8576        0.6687        0.7524        0.4726
     8      0.8674        0.7057        0.7896        0.4944
     9      0.8554        0.7009        0.7923        0.4748
    10      0.8376        0.6261        0.7741        0.4436
    11      0.8218        0.5827        0.7699        0.4236
    12      0.8212        0.5838        0.7750        0.4221
    13      0.8586        0.6553        0.7866        0.4166
    14      0.8286        0.6109        0.7616        0.3925
    15      0.8393        0.5625        0.7473        0.3660
    16      0.8207        0.5643        0.7416        0.3568
    17      0.8188        0.5546        0.7341        0.3486
    18      0.8354        0.5213        0.7415        0.3513
    19      0.8625        0.6456        0.7489        0.3633
    20      0.8605        0.6516        0.7655        0.3746
    21      0.8125        0.6259        0.7408        0.3789
    22      0.8041        0.6281        0.7038        0.3621

  MEAN      0.8468        0.6364        0.7611        0.4193

  S.DEV     0.0237        0.0453        0.0222        0.0498
```

APPENDIX J

STATISTICS FOR 1980 TARSLL MODEL

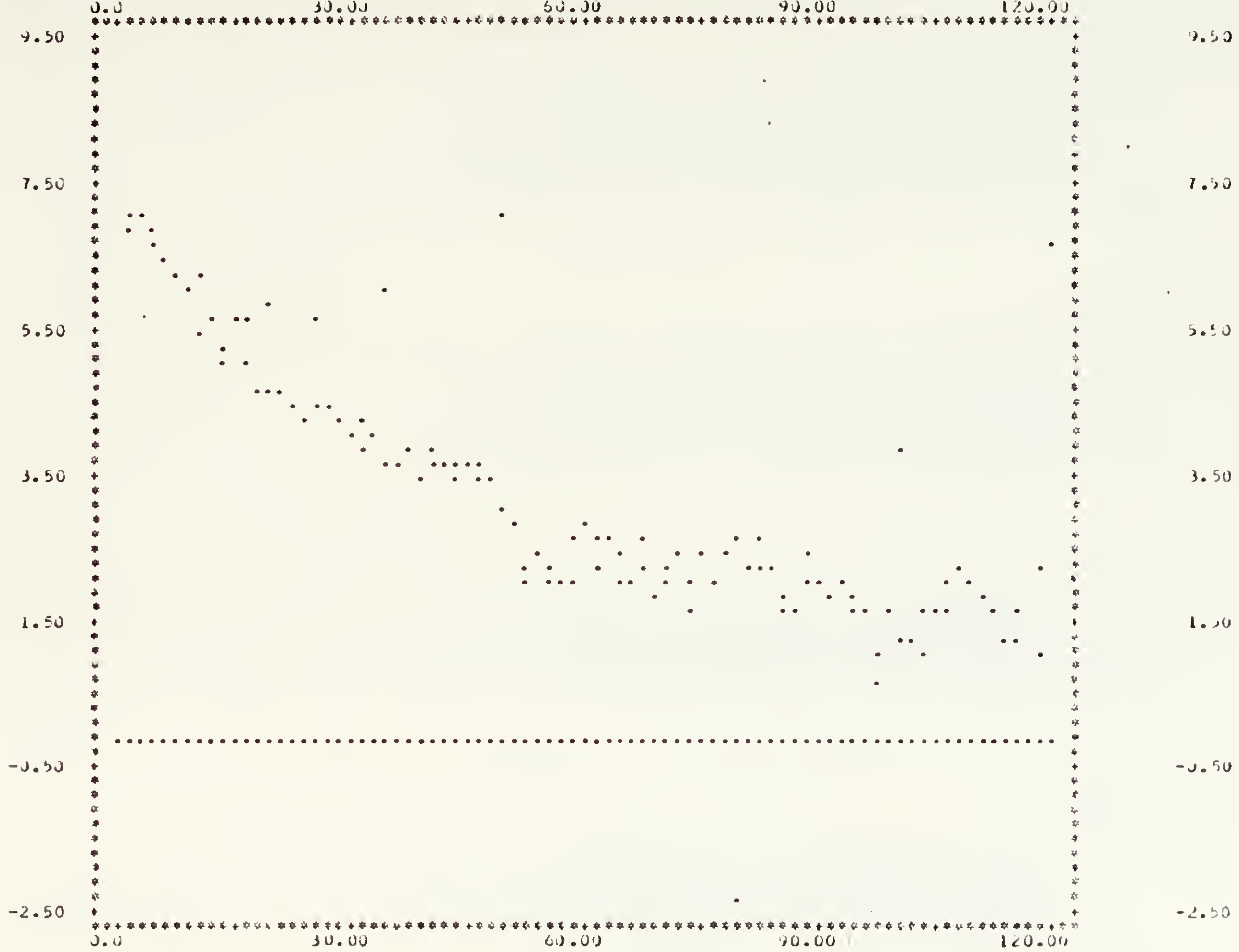
```
                   TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                                      NER            ER        TOTAL
CANDIDATES                          14567        139691       154258
LL RANGE                             2156         13010        15166
LL VALUE                          216394.       227917.      444311.
ADDS TO LL                           2156         13010        15166
ADDS VALUE                        216394.       227917.      444311.
DELETES FM LL                           0             0            0
DELETES VALUE                          0.            0.           0.
FORCED ON LL                            0             0            0
CONSTRAINED QTY                         0          1283         1283

          EFFECTIVENESS DATA
UNITS SAT                         130418.        68422.      198840.
REQN SAT                            2026.        18895.       20921.
DMD   LL                          141682.        75016.      216698.
      NLL                          41504.        21160.       52664.
      ALL                                                    279362.
FREQ  LL                            2483.        21183.       23666.
      NLL                           2805.         3050.        5855.
      ALL                                                     29520.
NET UNIT EFF                       0.9205        0.9121       0.9176
GROSS UNIT EFF                     0.7119        0.7114       0.7118
NET REQN EFF                       0.8160        0.8920       0.8840
GROSS REQN EFF                     0.3832        0.7797       0.7087

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                    2156          3867         6023
               NLL                  11327          9323        20650
               ALL                                             26673
BRF X POP      LL                       0          9143         9143
               NLL                      0        104191       104191
               ALL                                            113334
FORCED FCST    LL                       0             0            0
               NLL                   1034         13167        14251
               ALL                                             14251

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                          0             6            6
            NLL                      2248          6667         8915
            ALL                                                 8921
MIN RISK    LL                        171          3876         4047
            NLL                         0             0            0
            ALL                                                 4047

          OVERRIDES APPLIED
MANDATORY                               0             0            0
MAX QTY                                 0             0            0
MIN QTY                                 0             0            0
DELETE                                  0             0            0
```

STATISTICS FOR 1980 TARSLL MODEL



STATISTICS FOR 1980 TARSLL MODEL

```
DISTRIBUTION OF TRSL QTY      MAX QTY   17945.   NR NIIN ITEMS IS   14974   NR UNITS IS      713677
 1     2     3     4     5     6     7     8     9    10     1     2     3     4     5     6     7     8     9    20

598  1272  1219  1035   802   655   556   533   434   549   235   318   217   176   330   169   308   116   121   350    20
104    56    85    39   275    87    65    76    69    65    45    70    61   421    44    41    49    54    33    45    40
 39    43    33    36    44    43    34    35    22  1149    19    10     9    12    11     9     9     8    14    17    60
 14    10    16    12     9     8    11    14     7     8    10    12     9     6    12     8     8    12    15     0    80
 10    10    14    11     7     6     5    12     9     8     7     7     9     7     5     5     2     3     5    45   100
  4     4     3     5     6     9     5    10     8     1     7     5     6     4     4     6     1    11     3   753   120
```



STATISTICS FOR 1980 TARSLL MODEL

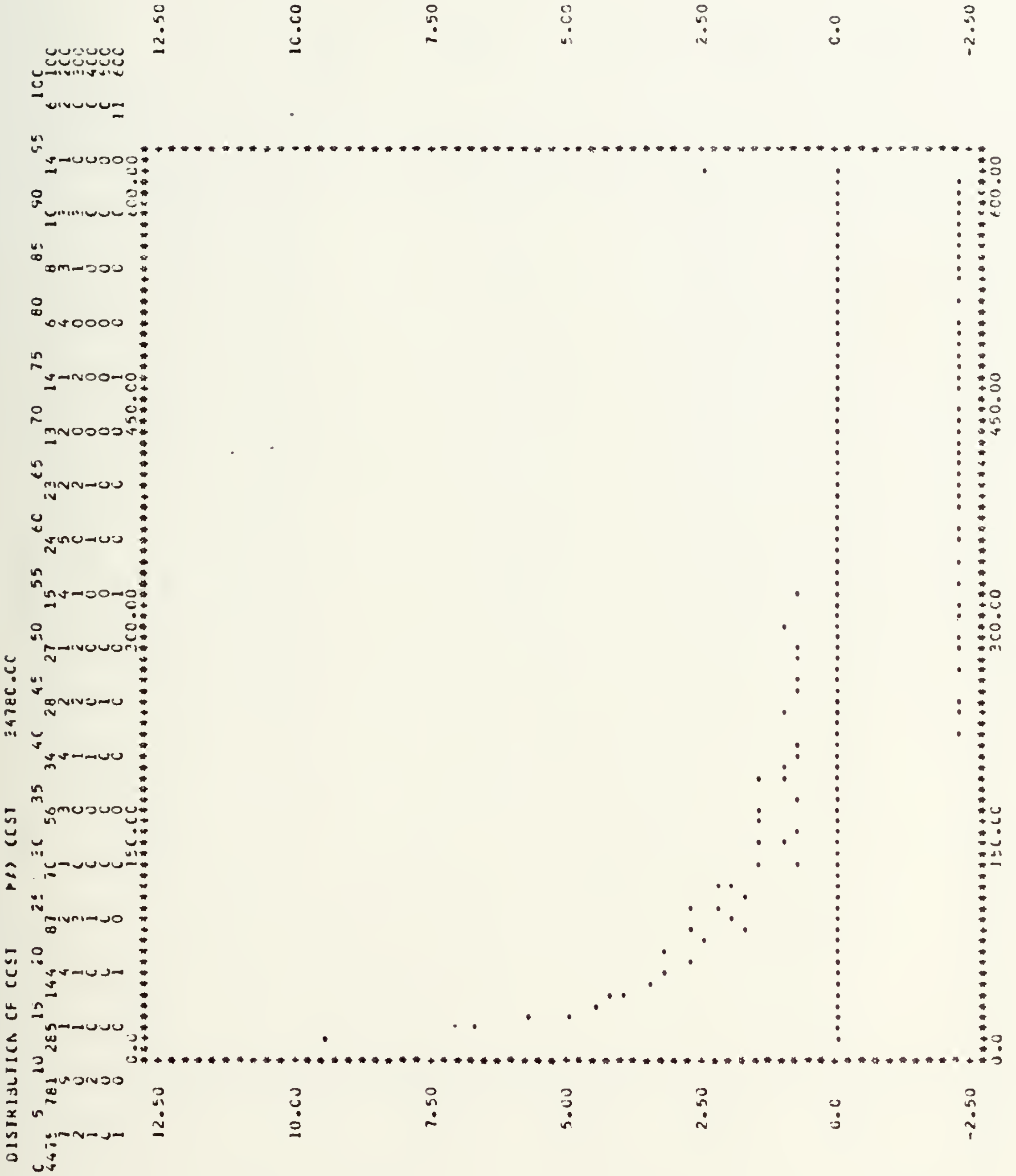
```
          LOAD LIST EFFECTIVENESS     ATLANTIC FLEET
  QTR     NET UNIT    GROSS UNIT     NET REQN     GROSS REQN

   1       0.8462        0.5956        0.8327        0.3588
   2       0.8503        0.6060        0.7981        0.3394
   3       0.8617        0.6213        0.8082        0.3533
   4       0.8418        0.6275        0.8006        0.3728
   5       0.8660        0.6563        0.8031        0.3817
   6       0.8388        0.6274        0.7839        0.3644
   7       0.8303        0.6192        0.7766        0.3588
   8       0.8384        0.6563        0.8059        0.3754
   9       0.8283        0.6503        0.8168        0.3604
  10       0.8079        0.5750        0.8044        0.3346
  11       0.7869        0.5381        0.7816        0.3167
  12       0.7815        0.5403        0.7823        0.3171
  13       0.8224        0.6111        0.7810        0.3160
  14       0.7906        0.5691        0.7485        0.2945
  15       0.8017        0.5213        0.7286        0.2751
  16       0.7900        0.5264        0.7218        0.2709
  17       0.7841        0.5149        0.7187        0.2680
  18       0.7996        0.5782        0.7201        0.2691
  19       0.8274        0.6025        0.7302        0.2787
  20       0.8246        0.6059        0.7340        0.2865
  21       0.7853        0.5851        0.7119        0.2888
  22       0.7772        0.5866        0.6854        0.2744

MEAN       0.8173        0.5917        0.7670        0.3207

S.DEV      0.0279        0.0428        0.0416        0.0404
```

APPENDIX K

STATISTICS FOR AS-FBM MODEL

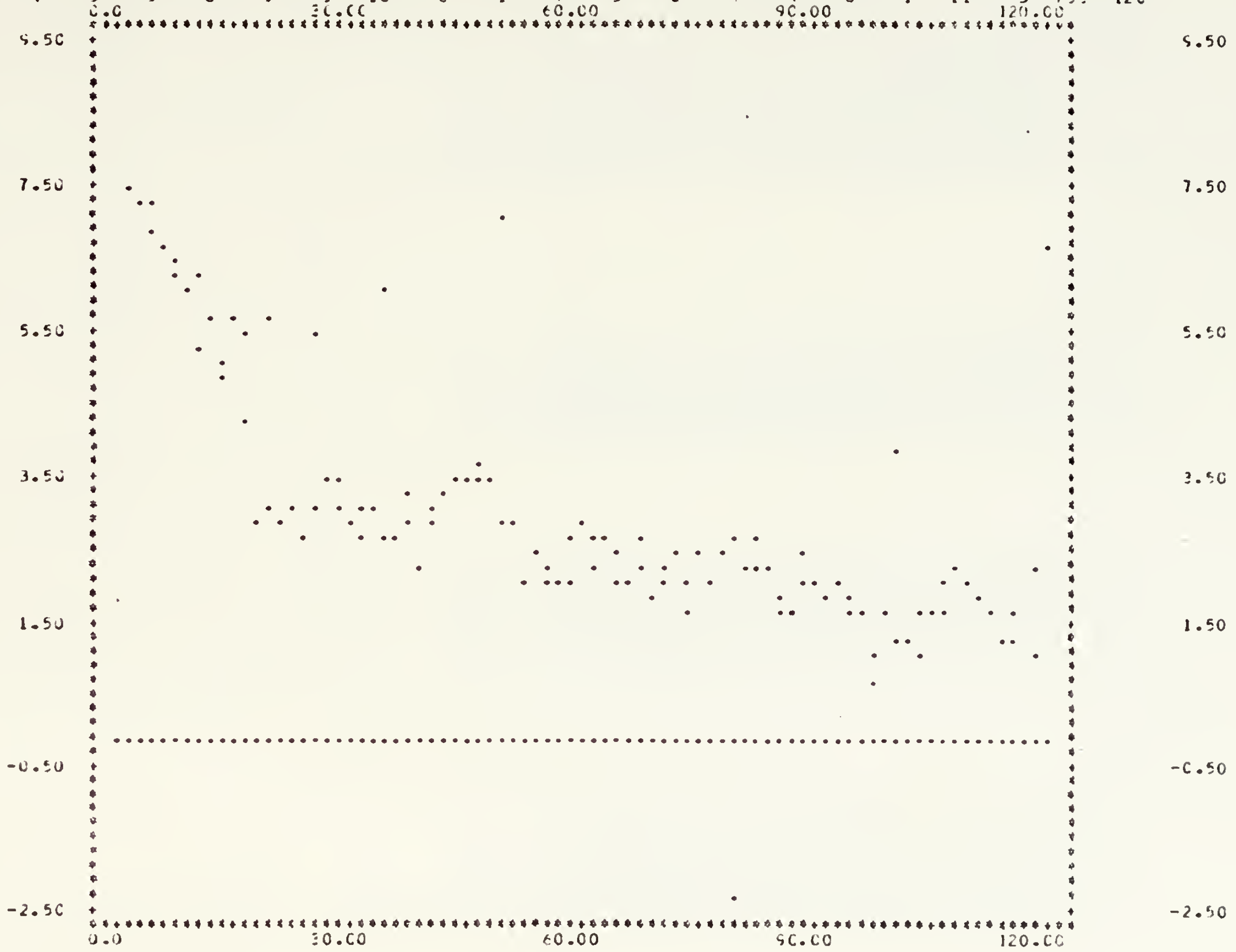
```
                    TRSLL LOAD LIST OUTPUT STATISTICS
   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.
                                  NEF            ER          TOTAL
CANDIDATES                      14567        139691         154258
LL RANGE                         2687         13538          16225
LL VALUE                      302505.       252988.        555493.
ADDS TO LL                       2687         13538          16225
ADDS VALUE                    302505.       252988.        555493.
DELETES FM LL                       0             0              0
DELETES VALUE                      0.            0.             0.
FORCED ON LL                        0             0              0
CONSTRAINED QTY                     0          1250           1250

          EFFECTIVENESS DATA
UNITS SAT                     132457.        71903.        204360.
RECN SAT                        2296.        20750.         23046.
DMD   LL                      144654.        78080.        222734.
      NLL                      38533.        18361.         56894.
      ALL                                                  279627.
FREC  LL                        2913.        22689.         25602.
      NLL                       2375.         2511.          4886.
      ALL                                                   30488.
NET UNIT EFF                   0.9157        0.9209         0.9175
GROSS UNIT EFF                 0.7231        0.7456         0.7308
NET RECN EFF                   0.7883        0.9145         0.9002
GROSS REQN EFF                 0.4343        0.8234         0.7559

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                2687          4287           6974
               NLL              10796          8903          19699
               ALL                                           26673
BRF X PCP      LL                   0          9251           9251
               NLL                  0        104083         104083
               ALL                                          113334
FORCED FCST    LL                   0             0              0
               NLL               1084         13167          14251
               ALL                                           14251

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                    382           366            748
            NLL                  1866          6307           8173
            ALL                                               8921
MIN RISK    LL                    171          3876           4047
            NLL                     0             0              0
            ALL                                               4047

          OVERRIDES APPLIED
MANDATORY                           0             0              0
MAX QTY                             0             0              0
MIN QTY                             0             0              0
DELETE                              0             0              0
```

STATISTICS FOR AS-FBM MODEL



STATISTICS FOR AS-FBM MODEL

```
DISTRIBUTION OF TASL QTY      MAX QTY  17545.   NR NIIN ITEMS IS   16030   NR UNITS IS      685010
  1    2    3    4    5    6    7    8    9   10    1    2    3    4    5    6    7    8    9   20

1794 1958 1920 1347  946  791  694  558  453  570  199  320  164  128  311   70  244   17   24  306   20
  19   23   23   14  243   21   34   30   23   18   15   23   24  407   15   15   20   28   11   22   40
  19   29   31   34   35   43   31   33   20 1146   17    9    9   12   11    9    9    8   14   17   60
  14   10   16   12    9    8   11   14    7    8   10   12    9    6   12    8    8   12   15    0   80
  10   10   14   11    7    6    5   12    9    6    7    7    9    7    5    5    2    2    5   45  100
   4    4    3    5    6    9    5   10    8    1    7    5    6    4    4    6    1   11    3  753  120
```



STATISTICS FOR AS-FBM MODEL

```
             LOAD LIST EFFECTIVENESS    ATLANTIC FLEET
   QTR      NET UNIT    GROSS UNIT      NET REQN      GROSS REQN

     1       0.8254        0.5942        0.7411          0.3638
     2       0.8306        0.6044        0.7199          0.3470
     3       0.8413        0.6197        0.7277          0.3610
     4       0.8216        0.6260        0.7256          0.3801
     5       0.8463        0.6555        0.7247          0.3895
     6       0.8192        0.6267        0.7088          0.3761
     7       0.8130        0.6181        0.7057          0.3715
     8       0.8256        0.6551        0.7430          0.3920
     9       0.8169        0.6497        0.7511          0.3794
    10       0.7918        0.5751        0.7229          0.3483
    11       0.7702        0.5364        0.6980          0.3259
    12       0.7660        0.5385        0.7006          0.3274
    13       0.8059        0.6089        0.7052          0.3243
    14       0.7747        0.5660        0.6723          0.3002
    15       0.7843        0.5183        0.6534          0.2794
    16       0.7741        0.5233        0.6424          0.2735
    17       0.7673        0.5118        0.6418          0.2701
    18       0.7826        0.5752        0.6406          0.2696
    19       0.8094        0.5993        0.6521          0.2793
    20       0.8073        0.6023        0.6562          0.2864
    21       0.7715        0.5836        0.6440          0.2917
    22       0.7625        0.5840        0.6091          0.2765

  MEAN       0.8004        0.5896        0.6903          0.3279

 S.DEV       0.0266        0.0434        0.0414          0.0445
```

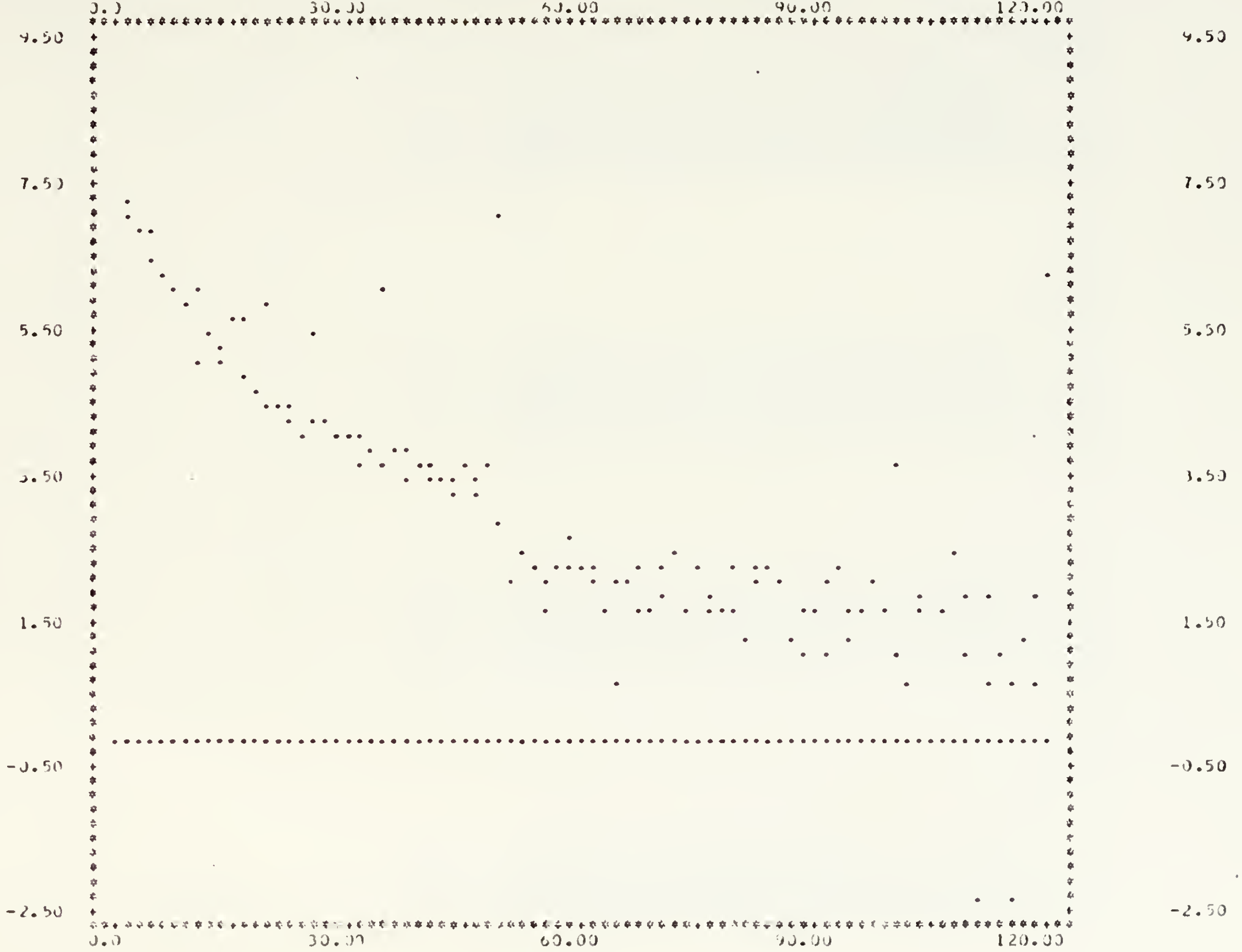
APPENDIX L

STATISTICS FOR MODEL WITH GAMMA DISTRIBUTION

```
                  TRSLL LOAD LIST OUTPUT STATISTICS
  LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                            NER           ER         TOTAL
CANDIDATES                 14567      139691       154258
LL RANGE                    2089       11615        13704
LL VALUE                 153442.     177072.      330514.
ADDS TO LL                  2089       11615        13704
ADDS VALUE               153442.     177072.      330514.
DELETES FM LL                  0           0            0
DELETES VALUE                 0.          0.           0.
FORCED ON LL                   0           0            0
CONSTRAINED QTY                0        1156         1156

        EFFECTIVENESS DATA
UNITS SAT                116239.      62166.      178405.
REQN SAT                   1619.      17006.       18624.
DMD  LL                  143433.      75969.      219402.
     NLL                  39753.      21516.       61268.
     ALL                                          280671.
FREQ LL                    2577.      21269.       23846.
     NLL                   2712.       2982.        5693.
     ALL                                           29539.
NET UNIT EFF              0.8104      0.8183       0.8131
GROSS UNIT EFF            0.6345      0.6377       0.6356
NET REQN EFF              0.6282      0.7995       0.7810
GROSS REQN EFF            0.3061      0.7012       0.6305

        AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL           2089        3475         5564
               NLL         11394        9715        21109
               ALL                                  26673
BRF X POP      LL              0        8140         8140
               NLL             0      105194       105194
               ALL                                 113334
FORCED FCST    LL              0           0            0
               NLL          1084       13167        14251
               ALL                                  14251

        NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK  LL                  38          49           87
          NLL               2210        6624         8334
          ALL                                        8921
MIN RISK  LL                 171        3876         4047
          NLL                  0           0            0
          ALL                                        4047

        OVERRIDES APPLIED
MANDATORY                      0           0            0
MAX QTY                        0           0            0
MIN QTY                        0           0            0
DELETE                         0           0            0
```

STATISTICS FOR MODEL WITH GAMMA DISTRIBUTION

```
DISTRIBUTION OF TRSL QTY      MAX QTY  15028.   NR NIIN ITEMS IS   13552   NR UNITS IS      616616
   1    2    3    4    5    6    7    8    9   10    1    2    3    4    5    6    7    8    9   20

1179 1415 1009  900  652  542  468  455  366  467  169  268  133  149  322  130  284  111   95  342    20
  32   85   77   65  255   70   70   60   57   53   43   58   54  424   37   43   47   30   43   40    40
  30   31   26   35   37   33   26   33   20 1109    9   13   13   11    6    9   11   11   14   10    60
   9   11    5    2    0    9   11    6    6    7   10   12    6    5   10    6    7    5   10    5    80
   4   10    8   11    1    8    4    3    6    6    7    3   10    5    4    5    8    8    5   40   100
   3    2    7    6    1    5    6   12    7    3    0    2    7    3    0    2    4    2    7  599   120
```



STATISTICS FOR MODEL WITH GAMMA DISTRIBUTION

```
           LOAD LIST EFFECTIVENESS     ATLANTIC FLEET
   QTR     NET UNIT      GROSS UNIT     NET REQN      GROSS REQN

     1      0.7970         0.5670        0.7308          0.3233
     2      0.8013         0.5769        0.7097          0.3087
     3      0.8145         0.5907        0.7242          0.3241
     4      0.7968         0.5977        0.7097          0.3405
     5      0.8150         0.6214        0.7114          0.3482
     6      0.7830         0.5902        0.6919          0.3355
     7      0.7772         0.5833        0.6955          0.3330
     8      0.7859         0.6191        0.7210          0.3517
     9      0.7714         0.6131        0.7286          0.3357
    10      0.7639         0.5520        0.7147          0.3086
    11      0.7423         0.5137        0.6949          0.2883
    12      0.7414         0.5145        0.6964          0.2884
    13      0.7365         0.5859        0.6974          0.2882
    14      0.7536         0.5441        0.6628          0.2643
    15      0.7609         0.4973        0.6422          0.2442
    16      0.7451         0.4980        0.6353          0.2390
    17      0.7384         0.4865        0.6371          0.2370
    18      0.7555         0.5486        0.6413          0.2378
    19      0.7831         0.5724        0.6465          0.2470
    20      0.7871         0.5786        0.6562          0.2560
    21      0.7398         0.5536        0.6316          0.2555
    22      C.7303         0.5524        0.6077          0.2439

  MEAN      0.7713         0.5617        0.6813          0.2909

  S.DEV     0.0256         0.0393        0.0378          0.0414
```

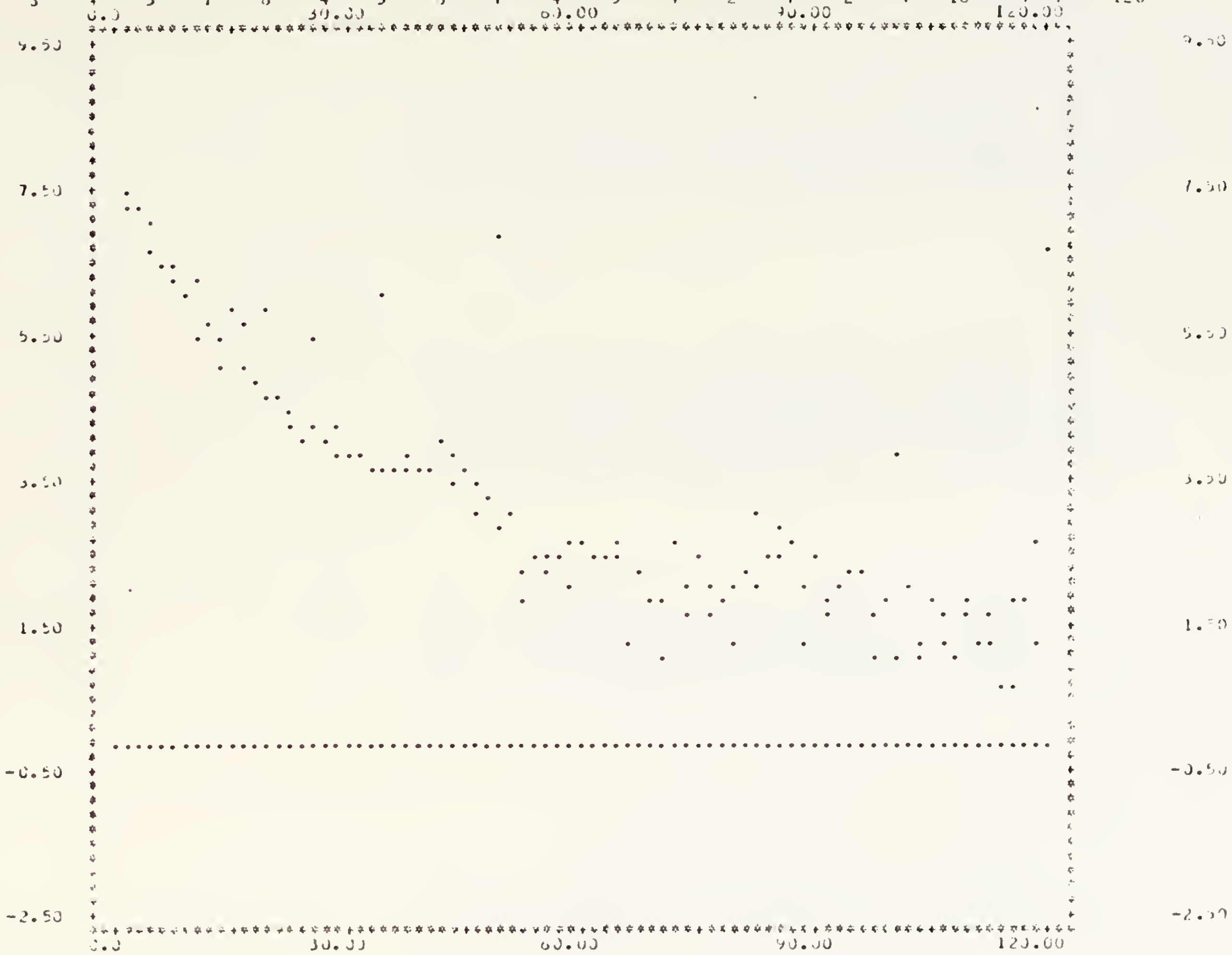
APPENDIX M

STATISTICS FOR UNITS SATISFIED MODEL

```
                         TRSLL LOAD LIST OUTPUT STATISTICS

   LE =  0.154  LN =  0.154  T =  1.0  K13 = 1.

                                    NER           ER          TOTAL
CANDIDATES                        14567       139691         154258
LL RANGE                           2708        13674          16382
LL VALUE                        167606.      123189.        290795.
ADDS TO LL                         2708        13674          16382
ADDS VALUE                      167606.      123189.        290795.
DELETES FM LL                         0            0              0
DELETES VALUE                        0.           0.             0.
FORCED CN LL                          0            0              0
CCNSTRAINED QTY                       0          324            324

         EFFECTIVENESS DATA
UNITS SAT                       131019.       67272.        198291.
REQN SAT                          1626.       18402.         20028.
DMD   LL                        143077.       76951.        220028.
      NLL                        40109.       31269.         71378.
      ALL                                                   291406.
FREQ  LL                          2127.       22956.         25083.
      NLL                         3162.        3273.          6439.
      ALL                                                    31522.
NET UNIT EFF                     0.9157       0.8742         0.9012
GROSS UNIT EFF                   0.7152       0.6215         0.6805
NET REQN EFF                     0.7647       0.8016         0.7985
GROSS REQN EFF                   0.3075       0.7015         0.6354

         AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                  2708         4981           7689
               NLL                10775         8209          18984
               ALL                                            26673
BRF X PCP      LL                     0         8693           8693
               NLL                    0       104641         104641
               ALL                                           113334
FORCED FCST    LL                     0            0              0
               NLL                 1084        13167          14251
               ALL                                            14251

         NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                        9           20             29
            NLL                    1700         6011           7711
            ALL                                                7740
MIN RISK    LL                      273         3377           3650
            NLL                       0            0              0
            ALL                                                3650

         OVERRIDES APPLIED
MANDATORY                             0            0              0
MAX QTY                               0            0              0
MIN QTY                               0            0              0
DELETE                                0            0              0
```

STATISTICS FOR UNITS SATISFIED MODEL

```
DISTRIBUTION OF TFSL QTY      MAX QTY  17945.   NR NIIN ITEMS IS   15199   NR UNITS IS       711673
   1    2    3    4    5    6    7    8    9   10    1    2    3    4    5    6    7    8    9   20

1334 1657 1430 1171  855  646  623  575  448  516  225  304  228  169  338  167  319  137  120  355   20
 111   95   77   65  265   71   62   74   53   49   54   43   42  414   39   42   49   41   30   40   40
  43   65   45   36   41   23   35   26   20 1076   21    7   10   13   10   12   13   14    9   15   60
  12   13   12   14   12    4   11   11    7    3    7   14    6    8   13    5    8    7    4    9   80
  11    5   24   12   20   12   14    8    4   12    6    7    9   10   10   11    3    5    7   46  100
   3    3    4    5    7    6    4    3    5    7    4    5    4    2    7    2    7   16    4  734  120
```



STATISTICS FOR UNITS SATISFIED MODEL

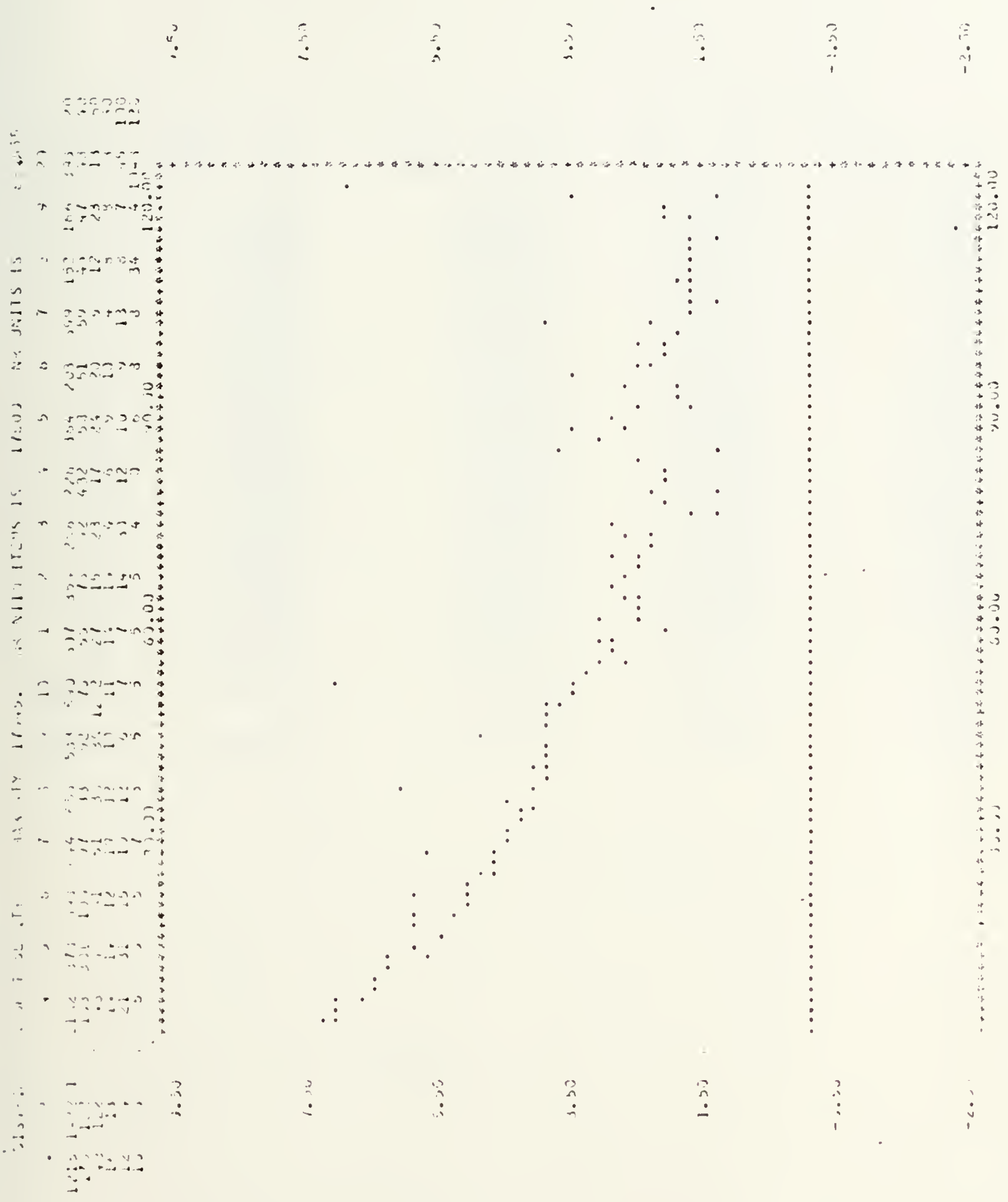
```
         LOAD LIST EFFECTIVENESS    ATLANTIC  FLEET
  QTR      NET UNIT     GROSS UNIT      NET REQN     GROSS REQN

   1        0.8249        0.5738        0.7389        0.2829
   2        0.8329        0.5929        0.7144        0.2728
   3        0.8440        0.6071        0.7188        0.2754
   4        0.8219        0.6133        0.7016        0.2848
   5        0.8467        0.6388        0.7237        0.2885
   6        0.8165        0.6102        0.7199        0.2742
   7        0.8072        0.6020        0.7186        0.2701
   8        0.8247        0.6461        0.7396        0.2835
   9        0.8157        0.6386        0.7443        0.2712
  10        0.7962        0.5625        0.7281        0.2535
  11        0.7796        0.5315        0.7145        0.2518
  12        0.7782        0.5392        0.7113        0.2625
  13        0.8167        0.6112        0.7163        0.2723
  14        0.7349        0.5668        0.6745        0.2498
  15        0.7893        0.5183        0.6436        0.2276
  16        0.7816        0.5252        0.6524        0.2257
  17        0.7775        0.5170        0.6589        0.2293
  18        0.7959        0.5828        0.6627        0.2389
  19        0.8208        0.6060        0.6647        0.2451
  20        0.8182        0.6101        0.6730        0.2544
  21        0.7749        0.5844        0.6569        0.2569
  22        0.7670        0.5847        0.6245        0.2413

 MEAN       0.8052        0.5847        0.6958        0.2597

 S.DEV      0.0237        0.0391        0.0353        0.0194
```

APPENDIX N

STATISTICS FOR UNIT EFFECTIVENESS MODEL, $\lambda = .154$

```
                    TRSLL LOAD LIST OUTPUT STATISTICS

   LE =   0.154   LN =   0.154   T  =   1.0   K13 = 1.

                                    NEW              SR           TOTAL
CANDIDATES                        14567          139691          154258
LL RANGE                           3354           14438           17792
LL VALUE                        726411.         376417.        1102828.
ADDS TO LL                         3354           14438           17792
ADDS VALUE                      726411.         376417.        1102828.
DELETES FM LL                         0               0               0
DELETES VALUE                        0.              0.              0.
FORCED ON LL                          0               0               0
CONSTRAINED QTY                       0            1316            1316

          EFFECTIVENESS DATA
UNITS SAT                       149533.          74923.         224461.
REQN SAT                          2906.          19677.          22583.
DMD    LL                       152721.          78794.         231515.
       NLL                       30465.          16734.          47200.
       ALL                                                      278715.
FREQ   LL                         3197.          21859.          25057.
       NLL                        2091.           2369.           4460.
       ALL                                                       29516.
NET UNIT EFF                     0.9792          0.9509          0.9695
GROSS UNIT EFF                   0.8163          0.7843          0.8053
NET REQN EFF                     0.9088          0.9002          0.9015
GROSS REQN EFF                   0.5494          0.8122          0.7651

          AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                  3354            5295            8649
               NLL                10129            7895           18024
               ALL                                                26673
BRF X POP      LL                     0            9143            9143
               NLL                    0          104191          104191
               ALL                                               113334
FORCED FCST    LL                     0               0               0
               NLL                 1084           13167           14251
               ALL                                                14251

          NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                        0               3               3
            NLL                    1131            5369            6500
            ALL                                                    6503
MIN RISK    LL                     1451            5554            7005
            NLL                       0               0               0
            ALL                                                    7005

          OVERRIDES APPLIED
MANDATORY                             0               0               0
MAX QTY                               0               0               0
MIN QTY                               0               0               0
DELETE                                0               0               0
```

STATISTICS FOR UNIT EFFECTIVENESS MODEL, $\lambda = .154$



STATISTICS FOR UNIT EFFECTIVENESS MODEL, $\lambda = .154$

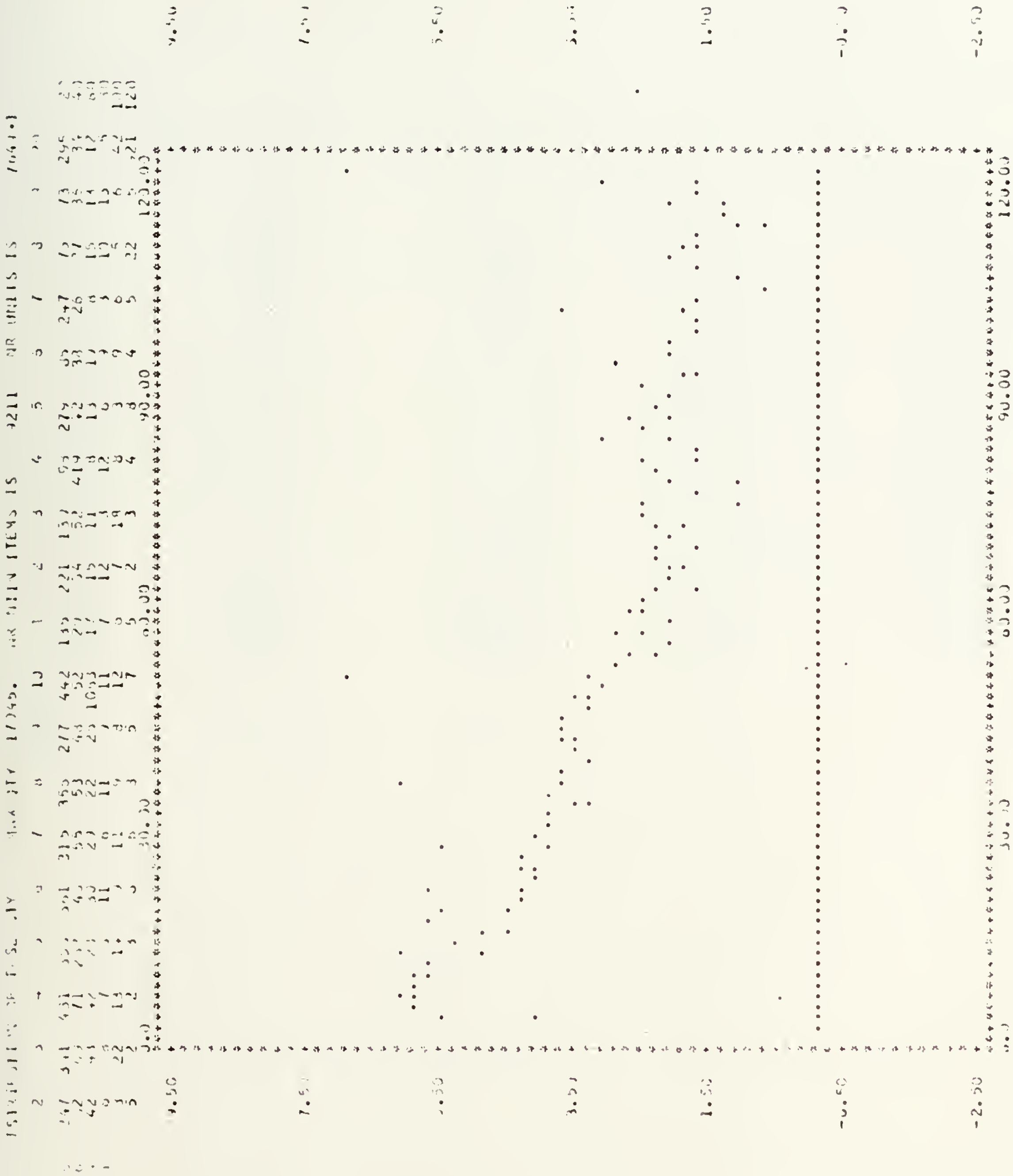
```
            LOAD LIST EFFECTIVENESS     ATLANTIC FLEET
   QTR      NET UNIT     GROSS UNIT     NET REQN      GROSS REQN
     1       0.8682        0.6435        0.8735         0.4496
     2       0.8764        0.6593        0.8465         0.4364
     3       0.8837        0.6712        0.8427         0.4469
     4       0.8633        0.6748        0.8371         0.4659
     5       0.8876        0.7016        0.8360         0.4722
     6       0.8637        0.6756        0.8334         0.4623
     7       0.8590        0.6698        0.8316         0.4568
     8       0.8667        0.7075        0.8639         0.4770
     9       0.8568        0.7021        0.8625         0.4553
    10       0.8400        0.6279        0.8469         0.4296
    11       0.8221        0.5859        0.8314         0.4151
    12       0.8174        0.5868        0.8285         0.4171
    13       0.8514        0.6598        0.8248         0.4152
    14       0.8205        0.6148        0.7963         0.3901
    15       0.8287        0.5662        0.7813         0.3668
    16       0.8137        0.5671        0.7770         0.3604
    17       0.8110        0.5576        0.7698         0.3526
    18       0.8292        0.6243        0.7670         0.3545
    19       0.8550        0.6483        0.7751         0.3660
    20       0.8541        0.6544        0.7865         0.3796
    21       0.8110        0.6287        0.7698         0.3827
    22       0.8021        0.6316        0.7335         0.3654

  MEAN       0.8446        0.6390        0.8143         0.4144

  S.DEV      0.0260        0.0448        0.0386         0.0430
```

APPENDIX O

STATISTICS FOR UNIT EFFECTIVENESS MODEL, $\lambda=2.10$

```
                    TRSLL LOAD LIST OUTPUT STATISTICS

    LE =  2.100  LN =  2.100  T =  1.0  K13 = 1.

                                  NER              ER            TOTAL
CANDIDATES                      14567          139691           154258
LL RANGE                         1857            7414             9271
LL VALUE                      324772.         140333.          465605.
ADDS TO LL                       1857            7414             9271
ADDS VALUE                    324772.         140333.          465605.
DELETES FM LL                       0               0                0
DELETES VALUE                      0.              0.               0.
FORCED ON LL                        0               0                0
CONSTRAINED QTY                     0             914              914

        EFFECTIVENESS DATA
UNITS SAT                     139677.          62285.          201962.
REQN SAT                        1697.          12603.           14300.
DMD   LL                      145348.          68276.          213624.
      NLL                      37838.          33686.           71524.
      ALL                                                      285148.
FREQ  LL                        2063.          15650.           17713.
      NLL                       3225.           3912.            7137.
      ALL                                                       24850.
NET UNIT EFF                   0.9610          0.9123           0.9454
GROSS UNIT EFF                 0.7625          0.6109           0.7083
NET REQN EFF                   0.8225          0.8053           0.8073
GROSS REQN EFF                 0.3209          0.6443           0.5755

        AVERAGE DEMAND COMPUTATION
HISTORICAL DMD LL                1857            2961             4818
               NLL              11626           10229            21855
               ALL                                               26673
BRF X POP      LL                   0            4453             4453
               NLL                  0          108881           108881
               ALL                                              113334
FORCED FCST    LL                   0               0                0
               NLL               1084           13167            14251
               ALL                                               14251

        NUMBER OF ITEMS RISK CONSTRAINED
MAX RISK    LL                      6              17               23
            NLL                  2615           12437            15052
            ALL                                                  15075
MIN RISK    LL                    527            1465             1992
            NLL                     0               0                0
            ALL                                                   1992

        OVERRIDES APPLIED
MANDATORY                           0               0                0
MAX QTY                             0               0                0
MIN QTY                             0               0                0
DELETE                              0               0                0
```

STATISTICS FOR UNIT EFFECTIVENESS MODEL, $\lambda=2.10$



STATISTICS FOR UNIT EFFECTIVENESS MODEL,λ=2.10

```
              LOAD LIST EFFECTIVENESS     ATLANTIC FLEET
     QTR       NET UNIT       GROSS UNIT      NET REQN       GROSS REQN

       1        0.8723         0.5921          0.8032          0.2735
       2        0.8743         0.6123          0.7948          0.2691
       3        0.8351         0.6260          0.7366          0.2794
       4        0.8603         0.6325          0.7345          0.2951
       5        0.8328         0.6615          0.8057          0.3024
       6        0.8555         0.6380          0.8036          0.2952
       7        0.8493         0.6334          0.8093          0.2373
       8        0.8553         0.6724          0.8252          0.3022
       9        0.8465         0.6620          0.8173          0.2803
      10        0.8292         0.5822          0.8123          0.2613
      11        0.8105         0.5463          0.7764          0.2491
      12        0.8034         0.5527          0.7995          0.2573
      13        0.8464         0.6209          0.7953          0.2536
      14        0.8152         0.5777          0.7625          0.2370
      15        0.8287         0.5309          0.7482          0.2169
      16        0.8134         0.5365          0.7538          0.2135
      17        0.8114         0.5263          0.7479          0.2160
      18        0.8288         0.5927          0.7426          0.2140
      19        0.8542         0.6174          0.7413          0.2134
      20        0.8532         0.6255          0.7523          0.2242
      21        0.8094         0.5989          0.7425          0.2365
      22        0.8007         0.5931          0.7145          0.2232

    MEAN        0.8405         0.6018          0.7793          0.2554

    S.DEV       0.0263         0.0431          0.0313          0.0312
```

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